NATURE

No. 4226 SATURDAY, OCTOBER 28, 1950 Vol. 166

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Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London
Advertisements only should be addressed to:
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone Number: Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

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SIGNIFICANCE OF TECHNICAL EDUCATION

REFERENCE has already been made in these columns (*Nature*, October 21, p. 661) to some points in the two reports dealing with technological and technical education and man-power in Great Britain which have been prepared by the Parliamentary and Scientific Committee. Other aspects considered also merit attention. The Committee suggests that an increased technical element in secondary education is needed, and that the number of secondary technical schools should be greatly increased. A great expansion of the opportunities in secondary modern schools for education with a technical bias is recommended as one of the most urgent tasks of the Ministry of Education. Increased provision of courses of a more practical nature in technical colleges, particularly part-time courses, is also needed, and such courses should lead to the award of certificates of the City and Guilds of London Institute in a large number of crafts and industries. Moreover, a detailed study of regional and local industrial needs is desirable before the Minister issues instructions to local education authorities to establish and maintain county colleges in accordance with the Education Act of 1944. The functions of these colleges in providing part-time day courses for those in the age-group 15–18 may to some extent overlap those of existing technical colleges.

The report on technical education and skilled man-power, however, scarcely does justice to the development of part-time release from industry for attendance at technical colleges to which the last report of the Minister of Education testified, and while it is true that close co-operation and understanding between employers, employees and technical colleges are essential to produce the results, the Parliamentary and Scientific Committee in this report does not seem to get to grips with the real problem of how the standard of technical education is to be raised and the technical colleges enabled to concentrate on their task of training the technicians, undistracted by that of training the technologists.

Many of the other recommendations of the Committee are unexceptionable; for example, it is true that more industrial firms must accept their responsibility for producing skilled craftsmen, by giving training in the technique of the various trades and in the manipulation and use of the necessary hand and machine tools. They must also develop a better organised system of practical training and apprenticeship schemes, which may include education at works schools which should be combined with education at technical colleges.

What is imperative, however, is the need for some reconsideration of the respective functions of the technical colleges and the colleges of technology, and of the quantitative contribution both have to make. Without an idea of the ratio to be established, we cannot hope to deal effectively with the further question of staffing the colleges. The Parliamentary and Scientific Committee does, indeed, note a tendency for apprentices and other young workers, particularly

in the engineering and building industries, to embark on national certificate courses, although they would gain much more benefit from a course leading to the award of a City and Guilds craft certificate. Far more important, however, may be the effect on the national interest of drawing away the young craftsman from the craft side of such industries into the drawing office and administrative side, with distortion of the balance desirable from the point of view of productivity and industrial development.

The seriousness of this tendency, under present conditions, should be the more apparent when it is viewed against a wider background. In a recent article in the *District Bank Review*, Mr. K. S. Lomax gave some figures to show that in twenty-two industries the proportion of administrators, technicians and clerks to operatives has, on an average, about doubled in the past forty years; and in most industries the proportion of staff to workers has risen two, three or four times as fast in the last decade as it did for thirty years before. Mr. Lomax's figures tend to slur the distinction we have just been stressing between technologist and technician, and it is by no means clear in his figures into which group the craftsman falls. Nevertheless, when all allowance is made for the fact that technologists themselves should be ranked as productive as well as the technician, and for the natural influence of increased mechanization in some industries, Mr. Lomax has directed attention to a disturbing factor which not only hampers productivity but also must be taken fully into account in framing any policy of technical education.

Whatever industry can do by way of training its recruits will, in fact, be of slight importance unless the educational policy pursued by the Government—and probably also its general fiscal and industrial policy—is one calculated to check such distortions. Every reasonable opportunity and encouragement must be given to the exceptionally gifted to enable them to qualify for higher positions by further training at a university or college of technology; but provision must also be made for the technical training and skill which are within the capacity of the average individual and which are required by industry in its recruits. The lead must come from the top.

That is equally true of the question of staffing schools, technical colleges and colleges of technology. Sir Ewart Smith remarked, in his paper before Section L (Education) of the British Association, on the growing unbalance between the rewards offered in industry and teaching, and the way in which numbers and quality of men offering themselves as science teachers in the schools are decreasing when the national interest requires an upsurge. The Parliamentary and Scientific Committee in its first report recognized the dependence of the quality of the staff obtainable for colleges of technology upon the salaries offered and the conditions of service; and urged the Minister of Education to invite the Burnham Committee to make provision for special scales to meet the situation in selected departments of colleges of technology. In this it is supported by a passage in the third report from the Advisory Council on Scientific Policy.

In its second report, also, the Committee urges on the Ministry of Education that improved recruitment to the full-time teaching staffs of the technical colleges can only be obtained by improving the salary and superannuation conditions sufficiently to attract teachers with experience and qualifications which would bring them advancement in industry, and to facilitate interchange between college and industrial staff. That condition may well be even more important in the technical colleges than in the colleges of technology; but in neither sphere can the extension of the practice of industrial firms allowing qualified men on their staffs to act as part-time day teachers make more than a minor contribution towards alleviating the present shortage. The proper use of such part-time teachers appears to lie rather in the teaching of special highly technical subjects, when the pace of advance necessitates teaching being given from within the industry and is accordingly most appropriate for advanced lectures in the colleges of technology, as indeed was suggested in the Percy Report.

The dependence of the economic position of Great Britain upon technical education in its broadest sense is made sufficiently plain in these reports and in Sir Ewart Smith's paper. The Parliamentary and Scientific Committee's reports further indicate certain ways in which industry could improve the position, and they give a clear lead also to professional bodies. They indicate, too, the vital part which the Ministry of Education has to play and the importance of giving that Ministry the power and resources to ensure that over the whole country technical education is raised to, and maintained at, the highest possible standard. It is to be hoped that the Parliamentary and Scientific Committee will examine further the question of keeping technical education quantitatively in balance with technological education, and the latter with university education, and all three in some reasonable relation to the nation's estimated resources in man-power and woman-power, its reserves of talent and its needs for trained men and women at all levels and on all sides of national work.

Such questions are well within the competence of that Committee; but the question of dealing with those psychological factors which hinder the full utilization of technical development and invention, or which tend to deflect the craftsman or technician away from the workshop or factory, where the national interest demands his services, to the office or other non-productive posts which carry at present more social prestige, is a much wider one. If here again Government policy might do something to give a lead, the fundamental requirement is a sustained educational policy directed to create an informed public opinion and to correct the social values which are responsible for the undesirable differentials in status. Government policy and action, in education and in other fields, are important in determining the distribution and magnitude of technical skill and craftsmanship and the efficiency of industry. The full realization of the benefits which the wider and earlier application of scientific discovery and technical invention could bring to industry

and to the nation as a whole does not, however, entirely depend on Government policy and on fiscal, economic or technical factors. It depends equally on a spirit of co-operation and a receptivity to new ideas in the rank and file of industry as well as in its leaders; and it is for the scientific worker and technologist to play his own part as a citizen in the formation of the public understanding and goodwill in which such co-operation and receptivity flourish.

SCIENCE THROUGH THE POET'S MIND

Science and English Poetry

A Historical Sketch, 1590–1950. By Douglas Bush. (Patten Lectures, 1949, Indiana University.) Pp. ix + 166. (New York and London: Oxford University Press, 1950.) 16*s*. net.

THE book under notice being a very personal one, a personal note may perhaps be permitted in this review. Accordingly I will confess that the name of Prof. Douglas Bush was unknown to me when I took up "Science and English Poetry", although I have since found that this is not an admission that does me credit. Having in the past received the impression that many—or, say, some—of those who write professionally of poetry rather dislike it, although they find it an apt subject for a display of arid learning: having found that they sometimes write a rather turgid and troublesome English and, further, that they, in general, know nothing of science, it was with no very lively anticipation of pleasure that I began my reading. Let me say at once that I was speedily won over by the author. It is clear that, in spite of his very extensive reading and his professional concern, he has a strong liking for poetry: he writes a simple, charming and direct style, enlivened by a polished irony: he knows quite enough of science for his purpose—although he twice seems to imply that universal gravitation and terrestrial magnetism are much the same thing.

And what is his purpose? To trace the influence of the main developments of scientific thought and discovery on the English poets: to analyse the attitude of poetic minds, engaged in contemplating the problems of man's nature, destiny and environment, towards the findings of the natural philosophers. Beginning with the Elizabethans, he points out that the work of Copernicus and Tycho Brahe had little influence on Shakespeare and his contemporaries: in fact, it is probably true that, for the active intelligences of the England of the sixteenth century, experimental and observational science had about as much authority as poetry has to-day for the leaders of thought. The Elizabethan poets were content with the medieval scheme of things. Later, Donne's writings show from time to time an imagery borrowed from contemporary science, while Milton had, perforce, to busy himself with astronomical exposition through the mouth of Raphael and in such passages as that leading up to the Paradise of Fools—

> "They pass the Planets seven, and pass the fixt,
> And that Crystalline Sphear whose ballance weighs
> The Trepidation talkt, and that first mov'd;"

The poet's general attitude is, however, summed up at the beginning of "The Argument" to Book VIII: "Adam inquires concerning celestial Motions, is doubtfully answer'd, and exhorted to search rather things more worthy of knowledg".

It was with the spread of a knowledge of Newton's work that scientific thought became a real influence on contemporary poetry. Apart from the impression which Newton's individual discoveries made on the poets, a subject to which Marjorie Nicolson's recent book "Newton Demands the Muse" directed attention, for most eighteenth-century minds Newton was the man who revealed order and design, of divine origin, running through all creation. Newton himself said in the "Principia": "This most beautiful System of the Sun, Planets and Comets, could only proceed from the counsel and dominion of an intelligent and powerful being. . . . And from his true dominion it follows, that the true God is a Living, Intelligent and Powerful Being; and from his other perfections, that he is Supreme or most Perfect"*. This was the general implication that James Thomson, for example, saw in Newton's work, and Young, of the famous "Night Thoughts", likewise saw devotion as the daughter of astronomy. The romantic revolt of the early nineteenth century, of Coleridge and Wordsworth and Keats, was, then, as the author says, a revolt against a misinterpreted Newton, against the purely mechanistic and material scheme of things which so incensed Blake—who, it is safe to conjecture, never read the "Principia" or the "Opticks".

In the nineteenth century evolution was the scientific theme that imposed itself upon the intelligent world as much as Newton's discoveries did in the eighteenth. Tennyson pondered profoundly upon the meaning of this doctrine for man's spirit. Before Darwin's "Origin of Species" appeared, Lyell's "Principles of Geology" and Chambers's "Vestiges" had already contended that natural law had governed the changes that had taken place in organic and inorganic Nature since the creation, and "In Memoriam" contains in moving poetry the struggle of the poet's mind between faith and despair. "Shall man," he asks,

> "Who trusted God was love indeed
> And love Creation's final law—
> Tho' Nature, red in tooth and claw
> With ravine, shriek'd against his creed—
>
> * * *
>
> Who loved, who suffer'd countless ills,
> Who battled for the True, the Just,
> Be blown about the desert dust,
> Or seal'd within the iron hills?"

It must here be admitted that Prof. Bush appears to consider Tennyson to be a very fine poet, even better than the great poets of to-day, although, unlike most younger critics, he has read both, which is always liable to warp the judgment. In his last chapter he deals as sympathetically as may be with the modern poet, the "detached, isolated, hostile observer of society". He helpfully analyses present tendencies: "we must," he says "distinguish, if we can, between authentic obscurity and mere fashion; and—though it is not correct to say so—I think we must make a parallel distinction between authentic pessimism . . . and a fashionable cult of despair", and, after discussing Mr. T. S. Eliot, "For the modern recognition of

* Motte's translation, 1729.

man's plight has led in two opposed directions, to pleas for more science (and more social science) and to a religious revival". He bravely endeavours to do the right thing by Mr. Auden and Mr. Eliot.

There can be no doubt of the accomplishment, the charm of style and the interest of this book. The author is sometimes controversial: I am always on his side, but then I share Prof. Bush's admiration for Tennyson (no, we do not consider "The Idylls of the King" typical Tennyson) and am gratified to find cited Burton's "Anatomy of Melancholy", Drummond's "Cypress Grove", Robert Benchley and other favourites of mine. All those who concern themselves with the fluctuations in the attitude of intelligent minds to the fundamental problems of man's relation to Nature should read this book, even if they are indifferent to, or dislike, poetry. But they will get more out of it if they have a taste for poetry.

E. N. DA C. ANDRADE

PHOTOELASTICITY

Photoelasticity

By Prof. Max Mark Frocht. Vol. 2. Pp. xvii + 505. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1948.) 60*s*. net.

Photoelasticity

Principles and Methods. By H. T. Jessop and Dr. F. C. Harris. Pp. viii+184. (London: Cleaver-Hume Press, Ltd., 1949.) 28*s*. net.

PROF. M. M. FROCHT's book is the long-awaited second volume of his work, the first volume of which was published in 1941. It would probably be fair to say that, in contrast to the first volume, the emphasis in this book is strongly on elasticity. Two-fifths of the book is devoted to a consideration of various aspects of the theory of elasticity, presented in a manner which makes the subject thoroughly palatable to the engineer; the presentation shows every sign of the wide and successful teaching experience of the author. He deals specifically with stresses in semi-infinite and infinite plates, wedges and beams, and circular disks. He presents in each case a detailed comparison of photoelastic and mathematical results which should convince mathematicians of the validity of the photoelastic method, and experimentalists of the accuracy of the mathematical methods.

Prof. Frocht has also collected together the theoretical and practical evidence which justifies the use of plastic models to predict the stresses in components made of steel or aluminium. Other chapters are devoted to a discussion and exposition of the available experimental and mathematical methods of obtaining isopachic patterns. The isopachics are the contour lines of equal sums of principal stresses, whereas the ordinary photoelastic stress pattern, the isochromatics, defines the values of the difference between the principal stresses at all points. When both these patterns have been obtained, the values of the separate principal stresses can be computed.

The remainder of the book is devoted to a description of the techniques of three-dimensional photoelasticity, stress-'freezing', the use of light at oblique incidence, the use of scattered light, and a brief reference to the use of convergent light. An appendix contains details of the physical properties of 'Fosterite', a comparatively new photoelastic model material for use with the stress-'freezing' technique.

Colonel H. T. Jessop and Dr. F. C. Harris's more recent book on photoelasticity is a most welcome record of the revival of interest in photoelasticity at University College, London, where so much of the pioneer work in this subject was done in the days of Profs. Coker and Filon. This is a most useful text-book which provides the reader, in one volume, with the necessary elements of elasticity and optics, in the first half of the book, and much practical information on the apparatus used and the techniques employed, in the second half.

A brief discussion of the theory underlying the stress-'freezing' technique makes the limitations of the method very clear by setting out the necessary conditions of symmetry which must be fulfilled if the patterns obtained are to have any value other than the æsthetical appeal of their abstract beauty. There has been a good deal of confused thought on this subject, which should be clarified by the discussion in this book.

A very complete chapter on the photoelastic bench is likely to prove to be the most useful to the beginner, as the difficulties encountered with different optical systems are discussed lucidly and explained in detail.

E. K. FRANKL

FLORA OF THE CAPE PENINSULA

Flora of the Cape Peninsula

Edited by Dr. R. S. Adamson and T. M. Salter. Pp. xix + 889. (Cape Town and Johannesburg: Juta and Co., Ltd., 1950.) 55*s*.

THE editors, Prof. R. S. Adamson and Captain T. M. Salter, together with their collaborators, have provided in this work a descriptive flora of the best-known part of Cape Colony, namely, the Cape Peninsula. The area dealt with comprises 182 square miles and provides the home for an exceptionally rich flora, comparable to certain areas of Western Australia, and famous for its Ericaceous and Proteaceous shrubs.

The Cape Peninsula is only about one-fifth larger than the smallest English county, which has a recorded vascular flora of less than nine hundred species. But the habitats here considered range in altitude from sea-level to 3,549 ft. on Table Mountain, with a long coastal margin and diversity of inland conditions, while the rainfall may be less than 20 in. a year at the low levels or more than 80 in. on the mountains. It is true that, as the editors emphasize, the increasing population and especially the frequency of bush fires militate against the persistence of the native flora; but Table Mountain above the 1,000-ft. contour and the southern tip of the Peninsula have been proclaimed Nature reserves, which, if supported by public opinion, should materially assist in preservation.

The authors treat only of the flowering plants and ferns; but the total records of these number no less than 2,622 species, of which about 65 per cent are dicotyledons, 32 per cent monocotyledons, the gymnosperms account for six species and the ferns fifty-seven. Dichotomous keys are provided for the genera and for the identification of the species. For every species a brief description is provided, and a statement of the type of habitat, its frequency and period of bloom. The proof of the utility of such keys can only be fully assessed in the field; but the provision of a glossary should render them of assist-

ance, even to those with but a slight acquaintance with botany, and there can be no doubt that the authors have provided a work that will supply a real need.

Perusing these pages, it is of interest to note the representation of the various groups. Compositæ are, of course, by far the largest, while Leguminosæ, Iridaceæ, Cyperaceæ and Orchidaceæ follow. But the Ericaceæ are represented by one more species than the orchids, and no less than 102 are species of *Erica*. Another well-represented genus is *Oxalis*, with thirty-three species, of which all but a third are cited as frequent to very common, and only two as very local and one as rather rare. The species of *Erica* afford a striking contrast; only about a quarter are frequent or common, about thirty-two are occasional, sixteen species are local or very local, and twenty-five exhibit varying degrees of rarity and seven species have already become extinct. Here the need for active preservation, before it is too late, is obvious. Of the Proteaceæ, forty-three species are recorded as belonging to nine genera, of which about two-thirds are still frequent to common, a quarter grow occasionally or only locally, while nearly a fifth are rare to very rare. The Restionaceæ and Arizoaceæ are both well represented, the latter by ninety-four species, the former by eighty-six species, of which many are only found occasionally and a number are rare.

A ten-page introduction includes an all too brief account of the habitat conditions from which the absence of any consideration of the soils is to be deplored.

The text is clearly printed and the keys are easy to consult; and, having regard to the size of the work, the price is not unreasonable, doubtless due to the assistance afforded by the South African Council of Scientific and Industrial Research and the University of Cape Town, to which, as to the authors and editors, those interested in the flora of the Cape Peninsula owe a debt of gratitude.

E. J. SALISBURY

THE MATHEMATICS OF INTELLIGENCE

Human Ability

A Continuation of "The Abilities of Man". By Prof. C. Spearman and Prof. Ll. Wynn Jones. Pp. vii + 198. (London: Macmillan and Co., Ltd., 1950.) 16*s*. net.

"HUMAN ABILITY" was designed by the late Prof. C. E. Spearman as a continuation of the "Abilities of Man", published in 1927. Of the earlier book, an anonymous reviewer (*Nature*, **120**, 181; 1929) regretted that " . . . it is distinctly written for the layman, and he is expected to take many things on faith. He has to trust Prof. Spearman's mathematics and still more Prof. Spearman's arithmetic". Prof. Karl Pearson—for anonymity was no disguise, and the review is included in Morant's bibliography of his writings—was not prepared to trust either, and expressed his lack of confidence at some length elsewhere. It is to these controversies of the 'twenties that readers of "Human Ability" will find their attention often returning. It is not that later work is unacknowledged—the literature of the past twenty-five years has, in fact, been very fully ingested, if not always completely digested—but that this work is presented as a series of purely technical extensions of method and that important differences of opinion which have emerged about the status of mental factors are scarcely touched on.

Briefly, Spearman's thesis was that the uniformly positive correlations observed between different mental tests could be—and, for economy of hypothesis, should be—explained by two kinds of factor, a general factor G common to all the tests, and a series of specific factors S, each related to a single test. Later, other factors were admitted, which were intermediate in range, being represented in several but not all of the tests. "Human Ability" is partly a recapitulation and partly an attempt to bring the story up to date, describing the development of factor analysis at the hands of Spearman and others, and replying to the various criticisms which have been raised. In the latter part of its purpose, the book is not entirely successful. It is disappointing to find the interpretation of factors considered only in a narrow sense, and the biological reference of these statistical entities dismissed as "metaphysics". Similarly, the objections considered are largely those raised by Pearson and Thomson to the original two-factor theory—not the more radical criticism which in recent years has attacked the whole conception of factor analysis. On the technical side, the book will scarcely stand comparison with the accounts given by Thomson or by Holzinger and Harman, and it has less general interest than Burt's "Factors of the Mind" or Spearman's own earlier works. For the student some introduction to the subject from other sources is indispensable before reading "Human Ability".

The defects of the book are to some extent accounted for by the fact that it was unfinished at the time of Prof. Spearman's death; and Prof. Ll. Wynn Jones, who as part-author prepared the book for publication, has treated an incomplete text with almost excessive reverence. Many parts of the book seem to lack any consecutive theme; and it is difficult to believe that the brief paragraphs on the use of matrix algebra—to take one example—were meant to be published as they stand. If the book is in places little more than a skeleton, the bones are at any rate elaborately clothed. Prof. Spearman's crusading zeal is fully evident—in his comments, for example, on the extensive use now made of mental tests: "Voices are becoming more and more insistent", he writes, " . . . that the sway of the tests must be extended over the whole national man-power, woman-power, and child-power", a situation which "would appear to be promising, but not free from danger".

Many psychologists are more impressed by the danger than the promise; but whether we agree with Prof. Spearman or not, his views have been extremely influential, and no one interested in human abilities can afford to neglect his writings. Pearson credited him with "the merit of directing attention to the subject", and it is a subject in which interest has grown continuously. Pearson's fear that Spearman's advocacy would "do more harm than good if it leads the non-mathematical psychologist to believe that the author has proved his hypothesis" has fortunately not been confirmed. Non-mathematical psychologists who have interested themselves in the theory have been as active in criticism as in acceptance; and latterly, non-psychological mathematicians have made their contribution to the debate. Both have found in Spearman's work the stimulus of a coherent theory, but neither has been disposed to take much on trust.

A. D. HARRIS

The Heterocyclic Derivatives of Phosphorus, Arsenic, Antimony, Bismuth and Silicon

By Frederick George Mann. (The Chemistry of Heterocyclic Compounds Series.) Pp. ix+180. (New York and London: Interscience Publishers, Inc., 1950.) 42*s*.

THIS monograph is the first to appear of a series planned to cover the whole field of heterocyclic chemistry. Its scope is limited to a few rare classes of substance, and this has made it possible to present the facts in considerable detail within the compass of a small volume.

All types of cyclic compound having phosphorus, arsenic, antimony, bismuth or silicon as ring members are reviewed, but the arsenic derivatives, having been most studied, occupy two-thirds of the book. The arsenic analogues of most of the familiar polycyclic nitrogen ring systems have been prepared and are here described. The requirements of chemical warfare during and since the First World War no doubt gave an impetus to the study of arsenic compounds, and the sections on phenarsazine chloride and on the products of anti-lewisite reagents are noteworthy from this point of view.

Although this is a highly specialized book, it contains much that is of general chemical interest. In particular, a number of very interesting stereochemical studies by Mann, Turner and their colleagues are described. These include the preparation of the only known stable optically active quaternary phosphonium and arsonium salts and of an active *spiro*-arsonium salt; optically active phenoxarsine and phenoxstibine derivatives which owe their dissymmetry to molecular structures folded across the middle ring; and some special cases of *cis-trans* isomerism in palladium complexes and in dihydroarsanthrene derivatives.

The book is excellently produced and is generally free from errors; but a confusion has been noted in the numbering of formulæ on pp. 71–72. G. M. B.

Atmospheric Turbulence

By Prof. O. G. Sutton. (Methuen's Monographs on Physical Subjects.) Pp. viii+108. (London: Methuen and Co., Ltd., 1949.) 6*s*. net.

THIS monograph provides a clearly written account of the research which has been carried out during the past twenty years or so, largely in Great Britain and with Prof. O. G. Sutton in the van, on turbulence in the terrestrial boundary layer. The point of view is that of the mathematical physicist, but the mathematical equipment required of the reader is only slight.

Following a general introduction and a concise statement of the observed behaviour of the lower atmosphere (vertical gradients of temperature and wind velocity, eddy velocities and surface shearing stress), the reader is introduced to so-called K theory, an empirical treatment based on the assumption that turbulent diffusion is analogous to molecular diffusion but with an enhanced coefficient of transfer. Its limitations are quickly displayed, and the author then proceeds to show how the Prandtl–von Kármán ideas of the mixing path have been applied with some success to diffusion problems near the ground. Here the author's marriage of mixing-path theory with Taylor's theorem on diffusion by continuous movement is described. A final chapter is devoted to the effects of stable and unstable temperature stratifications and to natural convection.

The subject as presented here is still in the empirical stage. Because of its complexity, the essential physical bonds which must unite it to the basic laws of hydrodynamics and thermodynamics remain to be discovered; and if one has a criticism, it is that the author might have brought out this limitation of his treatment more clearly.

Minerals and How to Study Them

By the late Edward Salisbury Dana. Revised by Cornelius S. Hurlbut, Jr. (Dana's Series of Mineralogies.) Third edition. Pp. x+323. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 24*s*. net.

THE fourth and most elementary of the series of text-books by J. D. and E. S. Dana, covering the field of mineralogy, was first published more than half a century ago. This new revision retains essentially the characters of the first edition and remains a well-balanced introduction to the subject. The usual orthodox grouping is followed: chapters on crystallography and the properties of minerals lead to a systematic description of the more commonly occurring mineral species. Finally come short but adequate determinative tables. It is pleasing to find these tables subordinated to the description of the minerals and not, as has sometimes recently been the case, given undue prominence.

In revising the book, Mr. C. S. Hurlbut, jun., has shortened some of the introductory chapters and, in many respects a desirable change, has rearranged the description of the mineral species to follow the chemical classification—oxides, silicates, etc.—rather than listing together minerals containing the same elements. The volume is attractively produced and well illustrated with numerous diagrams and photographs. Newcomers to the science will find it a useful and stimulating introduction.

Artificial Radioactivity

By Prof. P. B. Moon. (Cambridge Monographs on Physics.) Pp. x+102. (Cambridge: At the University Press, 1949.) 12*s*. 6*d*. net.

IT is an extremely difficult undertaking to write a hundred pages on the main phenomena and techniques of radioactivity, even if these are limited to the medium and light nuclei, as the author states in the preface. The selection of what can be put of such an enormous field in such a small space must have been one of the main difficulties of the author. In my opinion, this has been solved, and a small book has been created, easily understandable and giving in some places much more than the pure fundamentals.

Identification and measurement of radiations and particles have been condensed into twenty pages, giving, of course, not much more than a very short description of the subjects.

The main emphasis is laid on the two other chapters—on radioactive processes in which the charge of the nucleus is being changed, and such processes where the charge of the nucleus does not change. In a condensed, but very clearly written, version the theories of β-ray spectra and of the electron-capture process are discussed. A good balance is maintained between theoretical considerations and experimental methods and results.

This is a book which should fulfil the aim to give a reader a clear short version of a number of advances in nuclear physics, without obstructing the view by insertion of too many details. HENRY SELIGMAN

THE HARWELL NUCLEAR PHYSICS CONFERENCE, 1950

TWO hundred and thirty delegates, of whom one hundred were from overseas, attended the International Nuclear Physics Conference held in the Clarendon Laboratory and Geography School lecture theatres in Oxford during September 7–13. In the five days of meetings nearly one hundred papers were given and there was much stimulating discussion both in and outside the sessions. In the confines of a short article it is possible to mention but a fraction of the papers and then only very briefly.

The sessions were divided into four main groups. On September 7 and 8, papers were given on the construction of high-energy accelerating machines and experimental work done with them, together with experiments in the allied field of cosmic radiation. The papers on September 11 and 12 were concerned with experiments at lower energies involving more modest accelerating equipment. September 13 was given to 'pile' physics, and, during the course of the meetings, alternative sessions on techniques, α- and β-ray spectroscopy, neutron spectroscopy and theoretical physics were held.

Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell, after welcoming the delegates, took the chair for the opening session on high-energy accelerators. The first paper, by Prof. L. W. Alvarez, reviewed the machine programme at Berkeley, California, and gave some experimental results. In particular, the differential p–p scattering cross-section has been found to have the value of 4 mB. per steradian at 90° and 340 MeV., and is independent of angle and energy in the range 200–350 MeV. The 60-in. cyclotron has been modified by Hamilton and Miller to accelerate carbon-12 nuclei and has been used by Seaborg to produce californium-244 and -246 from uranium-238. The method will probably lead to the production of further transuranium elements.

Prof. P. G. Kruger described the Illinois betatron, which was brought into operation in February and is giving an output of 1 R. per pulse, the maximum energy being 345 MeV. The Brookhaven proton synchrotron ('Cosmotron') is 80–90 per cent complete, and Prof. G. B. Collins discussed the difficulties which have to be overcome to obtain a beam.

Among machines brought into operation recently, Prof. E. T. Booth discussed the 385-MeV. Columbia cyclotron, Dr. U. Liddel (Office of Naval Research) the 340-MeV. synchrotron at the Massachusetts Institute of Technology, and Mr. M. Snowden the 170-MeV. Harwell cyclotron. At the Massachusetts Institute of Technology, experiments are planned to utilize the optical energy radiated from the accelerating electrons for studies in the region of 50–200 A., which has been neglected hitherto for lack of a suitable light source.

Meson physics was introduced by Prof. B. J. Moyer (California), who discussed the Berkeley evidence for the π^0 particle. An upper limit of 2×10^{-13} sec. can be set for the half-life of the particle and, from experiments on the γ-rays resulting from π^- meson capture in hydrogen, the mass of the π^0 meson is found to be $261 \pm 3\ m_e$. Capture of π^- mesons in deuterium does not lead to π^0 formation but yields neutrons according to the equations

$$\pi^- + \mathrm{D} \rightarrow n + n, \qquad (1)$$

$$\rightarrow n + n + \gamma. \qquad (2)$$

Reaction (1) is twice as likely as (2).

The Bristol value for the half-life of the π^0 meson was given by Mr. D. T. King as 3×10^{-14} sec., and Prof. G. E. Cosyns (Brussels) showed that in stars having more than twenty penetrating particles there is angular correlation between pairs. His results suggest, he said, that both multiple and plural production of mesons occur. Evidence for the V-mesons (both charged and uncharged) obtained by the Manchester group and by Prof. Anderson's group (California) was presented by Prof. P. M. S. Blackett, who suggested tentative decay schemes.

Further scattering and high-energy disintegration experiments were reported from Bristol, Harvard, Harwell and Rochester, but these will not be discussed here.

The theoretical session on high-energy physics was enlivened by the challenge of the new p–p and n–p scattering data where the results are in disagreement with the theory. Dr. A. Pais (Princeton) gave an admirable review of the position, and showed that the experiments can only be explained by introducing a strongly singular force between protons and a somewhat smaller one between neutron and proton. He stated that for spin-orbit coupling he favoured the potential well

$$\varphi(r) \propto \frac{1}{r}\frac{d}{dr}\left(\frac{\exp - Kr}{r}\right),$$

which is the meson-theoretical analogue of the potential encountered in atomic theory.

After a visit to the laboratories of the Atomic Energy Research Establishment, Harwell, on September 9, the week-end was taken up with social activities.

The Conference resumed on September 11, when Prof. T. Lauritsen, after describing the machines and spectrometers in use at the California Institute of Technology, gave up-to-date level schemes for oxygen-16, lithium-7 and the interesting mirror nucleus beryllium-7, the γ-ray from the 430-keV. level of which has now been observed. Reactions resulting from the bombardment of fluorine by protons have received much attention in the past, but new work is still being reported. Prof. S. Devons (London) gave results on the angular correlation between the α-particles and the pairs from the pair-emitting state of oxygen-16 which agree with Dirac theory assuming a spherically symmetrical field, and Mr. J. G. Rutherglen (Glasgow) showed evidence for a 12-MeV. γ-ray which suggests a low-lying level in the neon nucleus at $1{\cdot}53 \pm 0{\cdot}1$ MeV.

An ionization chamber in which wall effects have been eliminated has been used in Heidelberg for the study of energy-levels excited by a fast neutron flux. It was described by Prof. W. Bothe, who reported finding many new excited states of nitrogen-15. The reactions $O^{16}(dp)O^{17}$, $F^{19}(d\alpha)O^{17}$ and $C^{12}(dp)C^{13}$ have been used by Prof. J. Rotblat (London) to obtain level-schemes for carbon-13 and oxygen-17.

The results show a remarkable correlation between the energy states of the two nuclei for which it is difficult to account on theoretical grounds.

The major part of the afternoon session was devoted to the study of reactions involving tritium, either as a target or a bombarding particle. Prof. T. Bonner (Rice Institute), Dr. R. F. Taschek (Los Alamos Scientific Laboratory) and Mr. M. J. Poole (Harwell) have all investigated the energy-dependence of the cross-section for the D(Tn)He^4 reaction. It has a maximum value of about 5 barns in the region of 180-keV. triton energy. Mr. B. H. Flowers (Harwell) showed that strong spin-orbit coupling is necessary to account for such a large cross-section, and the calculated energy-dependence agrees with the experimental results if the accurate wave-functions of the Coulomb field are employed. Los Alamos experiments on the reactions T(pn)He^3 and T($p\gamma$)He^4 suggest the existence of a helium-4 level above 20 MeV. The T–T reaction, among the possible products of which are the dineutron and helium-5, is being studied at Los Alamos and Chalk River, but the experiments do not allow definite conclusions to be drawn at present.

A paper on ($p\gamma$) coincidence experiments using scintillation detectors having high resolution was given by Dr. W. E. Bureham (Cambridge). Applied to the reaction B^{10}(dp)B^{11}, counting-rates as high as 10 coincidences per microcoulomb of deuterons have been obtained.

The morning session of September 12 on angular distribution experiments and their interpretation was introduced by Prof. D. R. Inglis (Argonne National Laboratory), who outlined the theory with particular reference to the reactions Li^7($p\alpha$)He^4 and Li^6($d\alpha$)He^4. Analysis of these reactions shows that parities deduced from the nuclear models are correct; but disappointment was expressed that most of the information obtained relates to the highly excited state of the compound nucleus, which is in a region too complex to be treated theoretically. In a review of p–p and n–p scattering experiments in the region up to 30 MeV., Prof. J. H. Williams (Minnesota) showed they can be interpreted assuming that the purely nuclear scattering occurs only in states of angular momentum zero. Recent Minnesota experiments demonstrate that, in the region below 5 MeV., the 'effective range' between nucleons is independent of charge.

Dr. H. Wäffler (Zurich) described measurements of the separate angular distribution of the lithium 17·6- and 14·8-MeV. γ-rays, from which he concluded that the 17·6-MeV. level of beryllium-8 has even parity and odd angular momentum. Prof. P. Huber (Basel) discussed an experiment on the differential scattering cross-section of neutrons of about 3 MeV. energy by carbon, nitrogen and oxygen nuclei.

Related papers on the angular distribution of neutrons and protons from (dn) and (dp) reactions were given by Dr. J. Holt (Liverpool), who showed that there is a strong forward peak in both types of reaction, and by Prof. Rotblat, who has examined the angular distribution of the protons in (dp) reactions for various states of the final nucleus. The theory of these processes was treated by Mr. S. T. Butler (Birmingham), who showed how the angular distributions can be used to give the spins and parities of the nuclei involved. He invokes a stripping process and, by inserting certain boundary conditions, can predict the angular distributions to be expected for various values of spin and parity of the state of the final nucleus when these properties are known for the ground-state of the target nucleus. As an example he found from the experiments that the ground-state of oxygen-17 should be a $D_{3/2}$ or $D_{5/2}$ state.

The afternoon session on photodisintegration experiments was largely devoted to experiments with the deuteron. Dr. H. von Halban reviewed recent work in Oxford which still shows discrepancies with theory, and Dr. D. H. Wilkinson described Cambridge experiments with γ-rays extending from 4 to 17·6 MeV. and which lead to a value of the triplet range in good agreement with the figure reported later by Dr. Hughes. The disintegration C^{12}(γ3α) was described by Dr. V. Telegdi (Zurich), who found that, after going through a maximum at 18·5 MeV., the cross-section rises again as the energy is increased to 32 MeV. Mr. F. K. Goward (Harwell) discussed work on the reaction O^{16}(γ4α), which proceeds either as a ($\gamma\alpha$) reaction via an excited carbon-12 nucleus or as a fission-like process in which the oxygen nucleus breaks into two beryllium-8 nuclei. A new reaction, Li^7(γT)He^4, was reported by Dr. E. W. Titterton (Harwell), who gave a value for the cross-section of $1{\cdot}2 \pm 0{\cdot}6 \times 10^{-28}$ cm.^{2} at 17·6 MeV., and showed an excitation function indicating that the cross-section has a maximum value in the neighbourhood of 14 MeV.

The 'pile' physics sessions on September 13 were more concerned with research done with neutron beams than with the physics of piles. Dr. R. E. Bell described the Chalk River heavy-water pile, the neutrons from which have been used to excite γ-rays from neutron capture in hydrogen. From a measurement of their energy, the binding energy of the deuteron was found to be $2{\cdot}230 \pm 0{\cdot}007$ MeV., which is significantly higher than earlier values. The elegant experiments of J. M. Robson demonstrating the β-decay of the neutron were given detailed treatment. An allowed spectrum is found, the end-point being at 782 keV. Dr. D. J. Hughes described the Argonne 300-kW. pile and the newly completed Brookhaven 30-MW. pile. A high-speed mechanical chopper will be used with the latter for neutron time-of-flight experiments over a path-length of 20 metres. The device is expected to give a resolution ten times better than that of any previous chopper. Slow-neutron scattering experiments have allowed determination of the nuclear interaction triplet range as $1{\cdot}74 \pm 0{\cdot}1 \times 10^{-13}$ cm. and the singlet range as $2{\cdot}6 \pm 0{\cdot}5 \times 10^{-13}$ cm.

The Oak Ridge pile has been used for experiments on neutron diffraction and the decay of the neutron. Dr. A. H. Snell reported on both and gave scattering cross-sections and scattering efficiencies for various nuclei as measured by Wollan and Shull. At Los Alamos, the water boiler and fast reactor both operate at 10 kW. and give 10^{11} (slow) and 5×10^{12} (fast) neutrons/cm.^{2}/sec. respectively. After describing them, Dr. D. K. Froman discussed a proposed experiment to investigate the angular distribution of neutrons scattered by liquid helium II which, it is expected, will determine the statistics of the scattering nuclei.

Pile modulation techniques for cross-section measurement were discussed by Mr. D. J. Littler (Harwell) and Dr. L. Kowarski (Paris); and a stimulating paper on neutron beam magnetic resonance experiments was given by Prof. N. F. Ramsey (Harvard), who is currently using the method to determine the electric dipole moment of the neutron and the

neutron magnetic moment. Fission physics were treated in three papers: the first by Dr. J. C. Jacobsen (Copenhagen) on the fluctuations of charge on the fission fragments, the second on rare modes of fission by Dr. E. W. Titterton (Harwell) and the last, by Mr. J. Scott (Cambridge), on the theory of the fission process.

β-ray spectroscopy was treated in an alternative session. Dr. K. Siegbahn outlined the work in Stockholm on the internal conversion coefficients of certain isomeric transitions; he finds the results to be compatible with those expected on the shell model. Dr. H. O. W. Richardson described the spectrometers in use in Edinburgh, and Dr. S. C. Curran gave details of experiments in Glasgow, using proportional counters placed in a magnetic field, to examine β- and γ-ray spectra up to an energy limit of 2 MeV. Work at Harwell on gold-198 was reported by Dr. P. E. Cavanagh, and an experiment determining the internal conversion coefficient of an isomeric transition in bromine-82 was described by Mr. D. West. In the field of α-ray spectroscopy, experiments reported by Dr. S. Rosenblum (Paris) provided information on the nuclear radii of the $4n$, $4n + 1$ and $4n + 3$ radioactive series.

The neutron spectroscopy session included discussion of three types of time-of-flight spectrometer: the direct method of the mechanical modulator ('chopper') was described by Dr. Hughes; the modulated cyclotron, typified by the Columbia installation, was discussed by Prof. W. W. Havens, who also reported a new measurement of the electron–neutron interaction potential as 5,000 ± 1,000 eV.; and Mr. A. W. Merrison discussed the Harwell equipment which employs a pulsed linear electron accelerator as a photo-neutron source. In addition, papers were given on neutron diffraction by Prof. K. Lonsdale (London), Dr. D. G. Hurst (Chalk River) and Mr. G. E. Bacon (Harwell).

The theoretical physics session was devoted to discussion of possible models of nuclear structure and their mutual relation. Prof. R. E. Peierls (Birmingham) explained some of the difficulties confronting the 'compound nucleus' picture, formulated first by Bohr; Prof. E. Wigner (Princeton) outlined the evidence which produced the concept of 'magic numbers', and the shell-structure models of the nucleus which have been suggested to explain these numbers; Prof. Inglis reported further work on the *j-j* coupling model. Prof. Peierls also directed attention to recent significant experiments at Chalk River by Kinsey *et al.*, which showed that some heavy nuclei have entirely unexpected properties more characteristic of simple light nuclei. There was considerable discussion on the relation of the shell-structure model to other models, and on the extent to which it might be explained by current ideas on nuclear forces, or whether new ideas had to be introduced to explain observed regularities. Prof. P. A. M. Dirac (Cambridge), outlining his new ideas in field theory, was of the opinion that a new fundamental concept is needed, and suggested it is more likely to be forthcoming as a result of studying particles about which we know most, such as photons and electrons, rather than the more obscure mesons.

The Conference dinner, presided over by Lord Cherwell, was held in the Great Hall of Christ Church on September 12, and was notable for fine after-dinner speeches by Sir John Cockcroft, Prof. S. K. Allison (Chicago) and Prof. Niels Bohr (Copenhagen).

E. W. TITTERTON

THE CONCEPT OF CULTURE

VERY appropriately, the proceedings of Section H (Anthropology) of the British Association began on August 31 at Birmingham with a discussion meeting on the concept of culture. This concept has recently acquired a somewhat indiscriminate currency among anthropologists, archæologists, psychologists and other social scientists. It has dominated the development of anthropology ever since Tylor, with a stroke of genius, borrowed the term 'culture' from German scholars and generalized it to include "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society"[1]. It has also remained the main link between the different branches of anthropology and allied disciplines as these have become more specialized in methods and subject-matter.

The meeting was opened by Dr. Phyllis Kaberry (University College, London) with a paper on the recent history of the concept in British anthropology. She pointed out that since Tylor's day social anthropology has been defined as the science of culture, a term covering the whole way of life of an aggregate of people inhabiting a particular locality. Artefacts, ideas, institutions, and modes of organisation in social and political groupings are all included in culture, which, as Tylor implied, constitutes a system of interrelated parts. This idea lay behind the crucial change which occurred at the beginning of this century when anthropologists turned from tracing hypothetical origins and evolutionary stages to intensive field studies of existing cultures viewed as complex functioning wholes. Malinowski and Radcliffe-Brown had exceptional influence on this development in Great Britain; and it is significant that up to about 1931 they appeared to have a common approach. Both described social anthropology as the study of culture, their major contribution being their emphasis on culture as "an integrated system"[2] and their insistence that customs, institutions, etc., must be explained, not by conjectural history, but by the part they play "within an integral system"[3]. The principles and concepts put forward by them has determined the type of field-work done by British anthropologists since 1920. The monographs of professional social anthropologists in the intervening years are not only rich in detail but also provide analyses of the nature and function of particular institutions in selected societies within the framework laid down by Malinowski and Radcliffe-Brown. Even recent work avowedly concerned with clarifying the concept of social structure must, from this point of view, be regarded as an important contribution to our understanding of culture.

But this work, continued Dr. Kaberry, is also a sign of a shift which gives cause for apprehension. A first break with the accepted view came when Malinowski himself, in 1931, outlined the theory later elaborated in his posthumous book, "A Scientific Theory of Culture"[4]. He now defined culture as "an instrumental reality which has come into existence to satisfy the [biological] needs of man", and for his former sociological definition of "function" substituted one in terms of the satisfaction of primary or derived needs. Obviously, biological, psychological and environmental factors enter as determinants in the universal occurrence of many social institutions, but in Dr. Kaberry's opinion social anthropology

must stick to its own conceptual tools in analysing social phenomena.

A different shift was expressed by Radcliffe-Brown in 1940[5], and afterwards. He now defined social anthropology as the "study of human society", of the "network of social relations" which make up "the social structure", and distinguished it from the study of culture, by which he appears, at present, to mean standardized, socially transmitted patterns of behaviour. The problems raised by this distinction are being keenly debated among social anthropologists. But, Dr. Kaberry concluded, its validity remains open to question. She preferred to retain the concept of culture to cover the whole way of life of a people, including their values, norms of conduct and principles of social organisation.

Dr. Glyn Daniel followed with a paper on the use of the concept of culture in prehistoric archæology. In the nineteenth century, prehistory was dominated by a geological approach and used the epochal ideas of the geologists as its main conceptual tool. Stratigraphy became the key to archæology, and a unilateral sequence of periods was devised. This rigid geological approach broke down at the turn of the century due to the realization of its inadequacy and to the influence of the culture-historical school of German anthropologists and geographers. At the present time the idea of culture is used in two senses in prehistoric archæology: first, that of the culture of prehistoric man which it studies; and secondly, that of the division of the remains of prehistoric man into separate cultures recognized by the distribution of artefact patterns in space and time. In both usages the prehistorian comes up against the difficulty that he is, in the main, studying material culture; he can make very few legitimate inferences about the social, moral and spiritual culture of prehistoric man. But bearing in mind this limitation, it is reasonable for the prehistorian to talk of the culture of prehistoric man. Dr. Daniel argued that it might not be reasonable to use "culture" in the second or partitive sense to call the persistent associations of artefacts "cultures"; and he quoted some prehistoric "cultures" that are defined on one or two artefacts only. A new nomenclature in prehistory—not derived from geology, history or anthropology—is, he thinks, much overdue, and in this nomenclature some new words should be found for these artefact patterns. He discussed briefly the recent American suggestions for replacing the word 'culture' in prehistory in its partitive sense.

Mr. E. L. Trist then presented the point of view of a social psychologist. In the study of interpersonal and inter-group relations in our own society, he said, both a concept of culture and one of social structure are necessary. Though the psychologist begins with 'people', as individuals or as members of groups, and the anthropologist with the social structure, they have common problems which provide a basis for the establishment of complementary insights. To introduce more general points, Mr. Trist outlined some observations arising out of a study of the longwall method of coal-getting. The complete task is spread over three shifts and different skill groups. The methods and conditions of work, though apparently excellent production engineering, tend to make each man an isolate. Paranoid phantasies, anxiety conditions associated with absenteeism, suspicion and intrigue, are generated. Why such a system has worked so long is a problem. Habituation and the compensation of being able to project one's own hatred into the hated system play a part. This example shows how psychological forces, both at the level of the group and at that of the individual, interact with cultural and structural forces to bring about a total but concrete 'field' with a dynamic pattern. The concept of culture enables the psychological and sociological constructs used in such a situation to be brought together. Such a concept, by contrast with that of social attitude[6], can be used for all psycho-social processes.

Comparing the two major conceptual schemes which have prevailed in the human sciences, Mr. Trist pointed out that the first, the concept of a psycho-physical system, utilized, for example, in *Gestalt* psychology and in psycho-analysis, is essentially non-social; whereas the second, that of the institutional system, is non-psychological. The concept of a psycho-social system brings in cultural phenomena as techniques in means-ends relations, including skills, attitudes and action systems of an emotional order. Cultural objects may be defined as artefacts external to the individual; and cultural patterns as internal—that is, persons and groups actively use them to take roles and make relationships in the institutionalized social system. Though they may be standardized, they also refer to unconscious internal objects from which influences act on to more conscious levels and so on to society. The concept of culture is essential to relate the psycho-social patterns carried by the individual to the institutions of society.

The general discussion which followed was introduced by Prof. M. Fortes. It is, he said, reassuring to find agreement between a social anthropologist, a prehistorian, and a social psychologist that the concept of culture is indispensable for the human sciences. The reaction among some anthropologists against its uncritical use has, nevertheless, been salutary. Field experience and comparative research have shown that what Rivers called 'social organisation' can be abstracted for analysis from the total way of life of any community. A number of general principles have, for example, been shown to hold for kinship systems irrespective of the specific customs, beliefs and values in which they are expressed in particular societies, as well as of technology and economy. The concept of social structure epitomizes this advance in theory. This enables us to reserve the term 'culture' to describe what is qualitatively distinct in the way of life of one community as compared with another. To get beyond mere description in the study of culture is as much a problem of psychology as of anthropology, and the approach suggested by Mr. Trist seems full of promise.

Mr. Miles Burkitt contended that a geological basis is fundamental for prehistory. It is essential, for the next fifty years, to collect the facts in their geological setting; the connexions between 'stages' can be threshed out later. Differences between contemporaneous and apparently alike 'cultures' are obscured through the loss of artefacts. The value of the idea of culture to the prehistorian is that it brings in the people who made the artefacts. He should remember that very different cultures may be concerned with the same things. Human life even in prehistoric times was very complicated. Ultimately, culture has a biological basis related to such facts as the orientation given to individuals by environment. Starting with the individual organism, there are various degrees of individuality. The highest degree is that of society, and culture is the expression of this.

Prof. Gordon Childe, though in agreement with Dr. Daniel's criticism of the use of the term 'culture', maintained that archæologists should study what anthropologists include under this concept. Artefacts are the fossilized remains of cultures such as can still be observed by anthropologists, and symbolize patterns of behaviour learnt within social groups just as language and custom is learnt. Though much is missing, an attempt can be made to reconstruct these behaviour patterns. But we have still to face the full difficulties of the concept. Culture conditions values and categories. The good, the true and the beautiful are relative categories given by society. We are bound to the frame of reference derived from our own culture and we are unable to get outside of it.

Lord Raglan brought the discussion to a close. He disagreed with the view that any culture is a unified whole. The customs, beliefs, artefacts, etc., making up a culture are always derived from many sources. Each element can only be understood if its history is traced. An institution like monarchy, for example, can only be understood by means of hypothetical history. M. FORTES

[1] Tylor, Sir E. B., "Primitive Culture" (London, 1871).
[2] Radcliffe-Brown, A. R., "The Present Position of Anthropological Studies", presidential address, Section H, British Association for the Advancement of Science, 1931.
[3] Malinowski, B., art., "Anthropology", *Encycl. Brittanica*, supp. vol. 1 to 13th edn., 1926.
[4] Malinowski, B., "A Scientific Theory of Culture" (Chapel Hill, 1944).
[5] Radcliffe-Brown, A. R., "On Social Structure", *J. Roy. Anthrop. Inst.*, **70**, 1 (1940).
[6] Thomas, W. I., and Znaniecki, F., "The Polish Peasant in Europe and America", 5 vols. (Chicago, 1918–20).

THE NERVE FIBRE: STRUCTURE AND FUNCTION

ON September 5, during the Birmingham meeting of the British Association, Section I (Physiology) held a discussion on the nerve fibre. Those taking part were Prof. J. D. Boyd (London Hospital), Mr. A. L. Hodgkin (Cambridge) and Dr. F. K. Sanders (Oxford).

In introducing the discussion, Prof. J. D. Boyd pointed out that the vertebrate peripheral nerve fibre is a composite structure. It consists of an axial core of protoplasm, which is an outgrowth of a nerve cell, and an ensheathing apparatus of greater or lesser complexity and which includes the sheath cells of Schwann and a variable number of additional, cylindrically arranged membranes, the precise nature of which is in some doubt. The structure of the axial core, or axon, was then discussed with special reference to its surface membrane (the axolemma, which has peculiar and most important physico-chemical properties) and the problem of the presence or absence of a fibrillar apparatus. Attention was directed to the recent work of Young and of Weiss, which suggests a slow turgor flow down the axon from the nerve cell-body. The enormous discrepancy between the volume of the axon and the volume of the nerve cell-body was emphasized, and it was indicated how this entailed some special mechanism for maintaining the integrity of the peripheral parts of the axon. The structure of the Schwann cells and of their relation to the axon was then discussed, and attention was directed to the work of Abercrombie and Johnston, which indicates some special affinity between the axon and the sheath cells. Surrounding the sheath cells is a collagenous and reticular cylindrical sheath, the neurolemmal or endoneural tube. This may be only the innermost layer of the fibrous tissue sheaths of the nerve. It has, nevertheless, important functions, more particularly in nerve regeneration. The connective tissue sheaths themselves have an importance in the study of nerve conduction, for in whole-nerve preparations they may distort potentials considerably.

Finally, the nature and structure of the myelin sheath and its segmental arrangement, with the resulting nodes of Ranvier, were discussed by Prof. Boyd. The recent work of Huxley and Stämpfli has demonstrated that, in myelinated fibres, the impulse probably passes, in a saltatory fashion, from node to node. A possible objection to this concept is the absence, frequently mentioned, of nodes in the central nervous system. Central nodes, however, have been described by many of the older investigators, and recently, using methylene blue, Allison, Feindel and Weddell and Hess and Young have verified their presence. Prof. Boyd stated that in osmic and silver preparation he has never observed typical central nodes. However, he showed lantern slides in which node-like appearances were present. His conclusion is that the available evidence indicates the presence of functional nodes in the myelinated fibres of the central nervous system, but that more work is required to establish the details of their structure and arrangement.

Mr. A. L. Hodgkin commenced his account of nervous conduction by pointing out that the problems involved have been studied by physiologists and physicists for more than a hundred years. At an early stage of these investigations it became evident that the passage of 'messages' along nerves is accompanied by an electrical change called the action potential. Subsequent study has shown that electric currents play an essential part in the process of nervous conduction. The investigations of a number of physiologists, notably Prof. E. D. Adrian, have established the fundamental facts relating to the behaviour of the action potentials in intact nerves and nerve fibres during their activity. Mr. Hodgkin discussed this behaviour with special reference to the amplitude and frequency of the electrical changes and to the velocity of their conduction along the nerve fibre. He indicated how fundamental such studies are in the study of nervous activity. By accepting the nervous impulse as a biological entity, and studying it as such, physiologists and neurologists have a basic technique at their disposal for the investigation of the nervous system as a whole and in relation to general bodily activity.

There is, however, another series of problems relating to nervous activity which can only be studied by concentrating on the individual nerve fibre in an attempt to explain the nature and mechanism of the nerve impulse itself. These problems are essentially physical and physico-chemical in nature, and can only be studied adequately by the utilization of new physical methods; these methods, however, make study of the problems none the less reputable. Mr. Hodgkin then discussed the nature of the action potential and how it can be studied. He directed particular attention to the contribution that has been made by Prof. J. Z. Young in introducing the giant axon of the squid to the field of experimental physiology. He then described how the resting potential of the surface membrane in these axons can be measured by the introduction of capillary electrodes

into their cut ends, care being taken not to touch the inner surface of the membrane. In the study of the surface membrane of muscle, which has many fundamental features in common with the corresponding membrane of the nerve fibre, Gerard and his collaborators have shown that an electrode can actually be inserted transversely through the membrane without interfering with its activity, provided that the tip of the electrode measures less than 0·5 μ.

Study of the action potentials in these ways has shown that they are developed at the surface membrane. In the resting state (squid giant axon) the transmembrane potential difference is some 50 mV., the interior being negative. During activity this potential difference alters and the interior reaches a peak of some 40 mV. positive to the external solution. Hence the total excursion is about 90 mV. The electrical changes are associated with a remarkable series of permeability changes involving in particular the ions of sodium and potassium. In the resting state there is a high concentration of potassium ions within the membrane and a high sodium-ion concentration external to it. During passage of the nerve impulse the membrane permeability alters, so that sodium ions enter the fibre and potassium ions leave. After passage of the impulse the resting-state conditions are restored by a secretory process which uses metabolic energy to pump out sodium and reabsorb potassium. Evidence was discussed which indicates that it is the interchange of the minute amounts of sodium and potassium ions concerned which provides the immediate source of energy for conduction of the impulse.

After an introduction in which he referred to the intimate biological relationships that exist between viruses and the cells they parasitize, Dr. F. K. Sanders discussed that group of viruses, called 'neurotropic', which preferentially attacks the nervous system. He pointed out that in some instances (for example, the poliomyelitis virus) such viruses even restrict their activity to certain groups of cells within the nervous system. Experimental study of the poliomyelitis virus is rendered difficult by the fact that it is normally infective only in man, the chimpanzee and certain monkeys; hence investigation of the behaviour of the virus in the body is severely limited. There is, however, a natural virus disease of mice, called spontaneous encephalomyelitis, which behaves in mice in a manner very similar to that of poliomyelitis in the monkey. It was stressed that there is no reason for considering the two diseases to be closely related. Nevertheless, study of the behaviour of the mouse virus might throw light on that of the virus of poliomyelitis.

Dr. Sanders then described experiments on the behaviour of the mouse encephalomyelitis virus following introduction of a 'severe' strain by direct inoculation into muscle. The events following such inoculations depend upon the quantity of virus inoculated and on the age of the mice. In adults, sufficient virus must be given to overcome a 'barrier' (probably situated at the nerve-muscle junction) to invasion by the virus; otherwise no infection of the central nervous system occurs. In very young animals, however, the virus is able to multiply locally in the muscle to an extent sufficient to overcome the 'barrier'. When the barrier has been overcome, the virus travels centrifugally along the actual fibres of the nerve supplying the muscle at a speed of about 0·5 mm. an hour. It does not multiply during this passage in the nerve fibres, but on reaching the cells of origin of the fibres multiplication commences. This multiplication occurs without obvious disturbance of the normal functions of the infected nerve cells. Only at the end of the cycle of multiplication are the cells destroyed with explosive suddenness. Paralysis inevitably follows and a large amount of new virus is released. When multiplication commences in a nerve cell, the virus is, as it were, 'dissembled' and seems completely to lose its identity and to be built into the cell structure. Later, however, some fundamental disturbance of the life of the cell occurs and this is accompanied by the dissolution of its structure and the appearance of more virus.

Dr. Sanders indicated that the nature of this process is a problem for the future; but he stressed the fact that if murine spontaneous encephalomyelitis is considered from the point of view of the virus, the whole infectious process is virtually over before the symptoms considered to be characteristic of the disease appear. There seems little doubt that this is also true of poliomyelitis.

HORMONES OF THE DIGESTIVE TRACT

POPULAR interest in the control of digestive functions has centred on Pavlov's demonstration of the reflexes, conditioned and unconditioned, which play such an important part in the regulation of salivary and gastric secretion. The hormonal control of digestion has aroused less general interest, and, although much of the pioneer work in this field was done by British physiologists, it was only at the recent meeting of the British Association in Birmingham that a presidential address to Section I (Physiology) was for the first time devoted to the hormones of the digestive tract.

The discovery of secretin, as Prof. R. J. Brocklehurst pointed out in his address, "was an eventful one, not only in connexion with the functions of the digestive system, but for Physiology as a whole. It was the first clear demonstration of the liberation of a chemical substance from an organ into the blood stream and its specific action on another organ. From this discovery, in fact, sprang much of the work on hormones of all kinds which has gone on during the first half of the present century and has become such an important branch of our science."

In the narrower field of the physiology of digestion, the discovery of secretin was the stimulus for two main types of investigation. On one hand, by cross-circulation experiments and by transplanting pieces of the stomach, pancreas and gall-bladder to other regions of the body (the transplants being cut off from their original nerve and blood supply), it was shown that during digestion hormones are released into the blood stream which stimulate the stomach and pancreas to secrete and the gall-bladder to contract. On the other hand, attempts were made to extract the active hormones from gastric and intestinal mucosa.

Prof. Brocklehurst surveyed the mass of work along these lines during the past fifty years which has established the existence of the hormones gastrin, which stimulates acid secretion by the stomach, secretin—the corresponding stimulant of the pancreas—and cholecystokinin, which brings about contraction of the gall-bladder. There is evidence,

too, that gastric activity, both secretory and motor, may be inhibited by the release of a hormone, enterogastrone, from the small intestine. Gastrin and secretin have no stimulant action on the output of enzymes in gastric and pancreatic juice. In addition to the well-established nervous control of digestive enzymes, these may also be influenced by hormones. Pancreozymin, present in extracts of intestinal mucosa, increases the enzyme output of the pancreas without affecting the volume of the juice, and there is some evidence for an analogous hormone for pepsin secretion by the stomach.

With the establishment by animal experiments of a number of hormones of the digestive tract, recent work has been concerned with the action of these substances in man, and with a more detailed study of the mode of their release during normal digestion. In the discussion following Prof. Brocklehurst's address, the actions and clinical uses of some of the gastro-intestinal hormones in man were considered by Prof. A. A. Harper (King's College, Newcastle upon Tyne). Three materials—secretin, pancreozymin and cholecystokinin—have so far been prepared in a form sufficiently pure for intravenous injection in man, and it has been shown that their physiological effects are the same as those in animals. To clinicians the interest of gastro-intestinal hormones lies in the possibility of their use in the diagnosis and treatment of disease. Recently, attempts have been made to treat peptic ulcer by the parenteral administration of the inhibitory hormone enterogastrone, but the majority of reports so far have been unfavourable. It has been claimed that the examination of the duodenal contents after secretin is of value in the diagnosis of malignant or chronic inflammatory lesions of the pancreas. At present, attempts are being made to increase the value of the secretin test in man by following the secretin by an injection of pancreozymin and cholecystokinin. A further improvement, as Prof. A. C. Frazer pointed out, would be to measure the activity of digestive enzymes in conditions comparable with those occurring in the intestine.

There has been increasing interest in recent years in the mechanism of the release of the digestive hormones. For the release of gastrin there is evidence of the importance of a local nervous mechanism, with a receptor in the mucosa which can be paralysed by the local application of procaine, and an efferent cholinergic fibre acting upon the cell which produces gastrin. Another line of attack on the problem is the study of absorption by the intestinal mucosa, since absorbed digestion products may carry some of the intestinal hormones into the circulation. In a discussion of the activities of the intestinal mucosa, Dr. R. B. Fisher stressed the very high metabolic rate of the mucosa, due in part to the work done in the active absorption of digestion products, and in part to the rapid multiplication of the cells of the mucosa, which in the rat may be completely replaced every thirty-six hours. It seems likely that the mucosa builds up peptides from absorbed digestion products of protein, and it is known that the hormones are also peptide in nature. Dr. Fisher pointed out that the presence of peptones in the gut leads to a build-up of proteins in the mucosa, and the application of injurious agents such as acid to the mucosa may lead to the breakdown of cytoplasmic protein. As these agents are known to bring about a release of hormones from the intestine, Dr. Fisher speculated upon the possibility that the hormones are normal products of the breakdown of mucosal cytoplasm, and that besides their specific hormonal activities they would "possess at the same time the generalized physiological activity of a specific building stone for the normal protein of the tissues".

This discussion undoubtedly served to stress the importance of the lining of the pyloric part of the stomach and the upper part of the small intestine as a prolific producer of hormones rivalling in number those of the anterior lobe of the pituitary gland.

OBITUARIES

Prof. E. A. Milne, M.B.E., F.R.S.

THE sudden death of E. A. Milne on the morning of September 21, in Dublin, while on his way to attend a colloquium convened in the rooms of the Royal Irish Academy by the Royal Astronomical Society, removes from our midst one of the great men of our time. Mathematician, astrophysicist, cosmologist, relativist and natural philosopher, Milne was endowed with a range of abilities and a depth of insight which, combined with his incredible energy and indomitable will-power, enabled him to maintain an astonishing outpouring of research of the highest quality and originality over a period of some thirty years, despite physical tribulations and personal misfortunes of a kind which would have overwhelmed a lesser man.

Edward Arthur Milne was born on February 14, 1896, the eldest son of Sydney Arthur Milne, of Hessle, East Yorkshire. He was educated at Hymers College, Hull, and at Trinity College, Cambridge, where he was elected to a prize fellowship in 1919, after serving during the First World War with the Anti-Aircraft Experimental Munitions Inventions Department and receiving the M.B.E. (In the Second World War he served at the Ordnance Board.) In 1920, H. F. Newall appointed Milne as assistant director of the Solar Physics Observatory in Cambridge. Four years later Milne succeeded Sydney Chapman as Beyer professor of applied mathematics in the University of Manchester, a post which he held until 1928, when he was appointed first Rouse Ball professor of mathematics at Oxford and fellow of Wadham College.

During his time at the Solar Physics Observatory and at Manchester, Milne's researches centred on problems of radiative equilibrium and the theory of stellar atmospheres. In 1922 he was awarded a Smith's Prize for a new treatment of radiative equilibrium replacing the earlier investigations of Schwarzschild. This work proved to be the starting point for many subsequent investigations by others. A by-product of mathematical interest was 'Milne's integral equation', which attracted the attention of J. E. Littlewood, G. H. Hardy and E. C. Titchmarsh. In 1923 Milne began a fruitful collaboration with R. H. Fowler on Saha's theory of high-temperature ionization. By modifying Saha's technique, they deduced that the pressures of the levels in stellar atmospheres at which absorption lines were formed were of the order of 10^{-4} atmosphere, a value considerably lower than had previously been assumed. Although much of this work was due to Fowler, the original key idea was Milne's. The theory was generalized by Milne in later papers.

While still at Cambridge, Milne began his well-known investigations on the equilibrium of the

calcium chromosphere under the balance of gravitational forces and radiation pressure. He discovered that for varying radiation from below the equilibrium was unstable, so that in certain circumstances atoms could ultimately be ejected from the sun with terminal speeds of the order of 1,600 km. per sec.

Milne's numerous memoirs on the opacity of stellar atmospheres culminated in his Bakerian Lecture of 1929. In the same year Milne took up his duties at Oxford, and during the following three years devoted his main energies to elaborating a theory of stellar structure based on a constructive mathematical criticism of the pioneer researches of Sir Arthur Eddington. In 1932 he delivered the Halley Lecture on "The White Dwarf Stars".

Meanwhile his interest had been aroused in the theory of the expanding universe, and in May 1932 he began that train of investigation which became the most original, the most controversial and the most far-reaching of the many theories associated with his name. He devised a new world-model which in its augmented form with a 'statistical component' appeared to be more fruitful than any of the homogeneous models hitherto produced by the 'orthodox' relativistic cosmologists. In particular, it provided an astonishingly simple explanation of Hubble's law correlating distance and velocity of recession, and also a possible gravitational explanation for the origin of cosmic rays.

Nevertheless, it is probable that that part of Milne's work in cosmology and relativity which will prove of the most lasting significance is the theory of time measurement by equivalent observers, on the basis of which new deductive systems of dynamics, gravitation and electrodynamics were developed in rapid succession. Associated with this work were two fundamentally novel ideas: the conception of different uniform scales of time operating in Nature, and the idea which first emerged from my analysis, arising out of Milne's generalization of my derivation of the Lorentz formulæ (itself suggested by remarks of Milne), that the fundamental group of equivalent frames is more restrictive than the six-fold infinite group of Newtonian and special relativity physics. The latter idea was explored further by Milne in his final contribution to the *Proceedings of the Royal Society* last year; but much still remains to be done.

It is impossible to convey here any detailed impression of Milne's many other contributions to stellar kinematics and dynamics, the kinematics and structure of spiral nebulæ, the theory of cepheid variation, etc.; it was characteristic of his courage that, although he knew his health was precarious, he made the journey to Dublin to read an exciting new paper on a relation, akin to Blackett's, connecting gravitation and magnetism, which had emerged from recent developments in kinematic relativity.

Apart from innumerable original memoirs, Milne published a long chapter on "The Thermodynamics of the Stars" in the "Handbuch der Astrophysik" in 1930 and three books: "Relativity, Gravitation and World-Structure" in 1935, "Kinematic Relativity" and "Vectorial Mechanics", both in 1948. He leaves two further books in manuscript: a life of Sir James Jeans, to be published by the Cambridge University Press, and a course of lectures which he was to have delivered at Birmingham this winter on the Edward Cadbury Foundation. He was also editor of the mathematical and physical sciences section of the series "Hutchinson's University Library".

Milne received many academic honours. He was elected a fellow of the Royal Society in 1926 at the age of thirty. He was awarded the Gold Medal of the Royal Astronomical Society in 1935, a Royal Medal of the Royal Society in 1941, and the Bruce Medal of the Astronomical Society of the Pacific in 1945. He was president of the London Mathematical Society during 1937–39, and president of the Royal Astronomical Society during 1943–45. He became an honorary member of the American Astronomical Society, a foreign honorary member of the American Academy of Arts and Sciences, both in 1947, and an honorary member of the Calcutta Mathematical Society in 1948. He was a D.Sc. (Oxon.) and an hon. D.Sc. (Amsterdam).

Milne was married twice. By his first wife, Margaret Scott (daughter of Hugh Fraser Campbell, of Dornoch, Sutherland), who died in 1938, he leaves two daughters and a son; by his second wife, Beatrice Brevoort (daughter of William Whetten Renwick, of New York), who died in 1945, he leaves a daughter.

Small in stature, Milne was outstanding in every other way. His penetrating and original intellect was sustained throughout many personal misfortunes by remarkable courage and unshakable religious conviction. Despite his brilliance of mind and widespread recognition, he retained a great humility and simplicity of character. To his research students, particularly to those of us who knew him in his prime, he was an unfailing source of inspiration. He was always the kindest and most conscientious of supervisors and collaborators. We mourn the passing of a leader among men of science and a pioneer among philosophers of Nature. G. J. Whitrow

Dr. D. H. Bangham

Physical chemistry, and perhaps more specifically fuel technology, have suffered a grievous loss by the death on July 29, at the early age of fifty-five, of Dr. Donald Hugh Bangham, director of Research Laboratories, British Coal Utilisation Research Association. His health had not been good for some little time; but his end came rather suddenly and as a sad blow to his immediate colleagues.

The quality of his mind was evident at an early age; in 1912 he won a scholarship in natural science to Jesus College, Oxford. Two years later he was commissioned in the King's (Liverpool) Regiment, attaining the rank of captain and gaining the Military Cross for leading an attack on the Hindenburg Line defences. Shortly after returning to academic life, he graduated with first-class honours and was appointed (1919) lecturer in physical and inorganic chemistry in the University of Manchester, where he published a number of papers concerned with rate-processes at the gas–solid interface; he revealed two characteristics: careful and elegant technique and a great power of generalization.

In 1926 Bangham accepted the chair of physical and inorganic chemistry in the newly founded Faculty of Science in the University of Cairo, where he was faced with the task of planning and equipping the laboratories, as well as preparing curricula. He served as dean of the Faculty during 1927–36, and on returning to England in 1937 he was awarded the Order of the Nile with the rank of commander.

Bangham joined the staff of the British Coal Utilization Research Association in 1938, almost at

its inception, and played a prominent part in recruiting scientific personnel and initiating their work. During the following twelve years he displayed outstanding leadership in researches concerned with the physical structure of coal and with the mechanism of its combustion. Previous approaches had been made by the analytical chemist and the geologist; Bangham followed the line that bright coal was a solid colloid, or an assembly of small particles too small to be visible under the microscope and imparting to the lump a porous structure. This conception has led to a model adequately accounting for the variation with rank of the properties of different coals. It has also been of great assistance in elucidating the complicated phenomena associated with solid fuels undergoing combustion; for example, 'reactivity'.

Two days before he died, Bangham was able to peruse a new work, "Progress in Coal Science", which he had edited; this work is a fitting memorial to his great ability and activity in editing for publication the considerable output of the British Coal Utilization Research Association.

Bangham was a great gentleman and a loyal colleague, whole-heartedly devoted to science and its industrial applications; and he gave much in exchange for little. Towards the end he fought against ill-health with a gallantry that evoked the esteem of all who knew him intimately; and he will be sorely missed. He leaves a widow, two sons and a daughter.

D. T. A. Townend

Mr. William Birtwhistle

Many visitors to the Cavendish Laboratory will have met Willie Birtwhistle, whose death occurred on September 25. For the past twenty years he had cared for the high-voltage accelerator of the Laboratory. He was trained in electrical engineering, and we were fortunate in being able to bring him to Cambridge when we started to build our proton accelerator in 1930. We had to instal a high-voltage transformer and exciting equipment, to build a voltage multiplying rectifier and accelerating tubes, and to apply the new technique of fast oil-diffusion pumps to our work. In all of this, Birtwhistle played a major part. A good deal of time had to be spent on finding leaks in the numerous seals which were then made by the use of low vapour-pressure 'Plasticine' developed for the work, and we will always remember the patience and care with which Birtwhistle thumbed the joints until the diffusion-pump spark discharge turned from pink to green and then finally to black.

In all the experimental work during 1932–37 with Dee, Gilbert, Lewis, Walton and myself, Birtwhistle took a full part. He always used to know what an experiment was about without being told, and he had always a very good sense of what was wrong when any trouble developed.

When the new high-voltage laboratory of the Austin Wing was built, he moved to the new laboratory and built and installed to Dee's design the one-million volt accelerating tube which worked with the Philips cascade generator. During the difficult years of the War the laboratory was kept going steadily for the work of the atomic energy project, and the return to academic work in 1945 was greatly helped by the loving care with which it had been tended.

Birtwhistle was a typical north countryman with a quiet humour and Yorkshire accent which was a pleasure to listen to. His patient ways and sound experimental sense inspired confidence in research students and helped many of them over their difficulties. He was a keen collector of stamps, and many research students who went overseas added to his collection.

Experimental physics owes much to its research assistants, and Willie Birtwhistle will take his place in their honoured roll.

J. D. Cockcroft

We regret to announce the following deaths:

Sir Sidney Harmer, K.B.E., F.R.S., director of the British Museum (Natural History) during 1919–27, on October 22, aged eighty-eight.

Prof. S. Sugden, F.R.S., professor of chemistry at University College, University of London, on October 20, aged fifty-eight.

Prof. Emil Votoček, emeritus professor in the Czech Institute of Technology, Prague, known for his work in organic chemistry, on October 11, aged seventy-eight.

NEWS and VIEWS

Cedergren Medal for 1949: Prof. R. Rüdenberg

Prof. Reinhold Rüdenberg, Gordon McKay professor of electrical engineering in Harvard University, has been awarded the gold Cedergren Medal and Scroll for 1949 for highly meritorious work in the field of electrical engineering. The Medal was founded by the Stockholm General Telephone Co. in memory of Henrik Tore Cedergren, director of telephony, and is awarded every five years for work in the art and science of electricity by the Royal governors for the universities of technology in Sweden. Prof. Rüdenberg, who is the eighth recipient of the Medal, was born in Hannover in 1883 and studied engineering at the Hannover Institute of Technology. He was an honorary professor at the Institute of Technology in Charlottenburg while he worked as chief electrical engineer of Siemens-Schuckertwerke in Berlin during 1923–36. He went to Harvard in 1939. In 1912 Prof. Rüdenberg was awarded the Montefiore Prize of the University of Liège for research on commutator machinery and in 1946 received an honour award medallion from the Stevens Institute of Technology for his work in connexion with the invention of the electron microscope.

Names of Chemical Elements

The names of chemical elements have been under consideration at the fifteenth congress of the International Union of Pure and Applied Chemistry which took place in September 1949 at Amsterdam. The report of the Congress is now available (Siège de l'Union, 28 Rue Saint-Dominique, Paris, 7e). The Commission on Inorganic Chemical Nomenclature made the following recommendations, which were adopted by the Union, for the newly discovered elements: Element 43 should be called 'Technetium' (Tc), 61 'Promethium' (Pm), 85 'Astatine' (At), 87 'Francium' (Fr), 93 'Neptunium' (Np), 94 'Plutonium'

(Pu), 95 'Americium' (Am), 96 'Curium' (Cm). In all these cases the guiding principle was to accept the names proposed by the real discoverers and to delete names like 'Masurium' or 'Illinium' which were adopted previously on account of spurious claims to the discovery of elements 43 and 61 (see *Nature*, 159, 8; 1947). An attempt was also made to remove some inconsistencies in the names of the older elements. The application of the same principle of historical correctness is here often difficult for lack of clear evidence, and also because it is open to debate how far it is advisable to change long-established names even if justice seems to demand it. A case in question is the name of element 71 (see *Ergeb. Exak. Naturwiss.*, 2, 168; 1923). In 1909 the International Atomic Weight Commission—consisting of Clarke, Ostwald, Thorpe and Urbain—wrongly accepted Urbain's name 'lutecium' instead of Auer von Welsbach's 'cassiopeium'; but since, in consequence of this decision, the former name has received wider recognition, one cannot but approve of its sanctioning by the Amsterdam Congress. Such practical considerations must weigh the heavier the more firmly established a name is. Other names proposed are: 4 'Beryllium' (Be), 41 'Niobium' (Nb), 71 'Lutetium' (Lu), 72 'Hafnium' (Hf), 74 'Wolfram' (W), 91 'Protactinium' (Pa). In view of the widespread use of tungsten not only in the laboratory but also in industry, practical considerations alone suggest that changing the name to 'wolfram' would be undesirable and cause confusion.

Northern Rhodesia Society

THE Northern Rhodesia Society has been formed with the object of promoting the study of various aspects, past and present, of Northern Rhodesia and its peoples. A major activity of the Society will be to publish the *Northern Rhodesia Journal*, which will appear twice a year and which, subsidized by the Government, will cost 5*s*. a copy. Such topics as Northern Rhodesian history, natural history, memoirs of 'old-timers', sociology and current developments will be covered, so as to supply something of interest both to the expert and the ordinary citizen. The *Journal* will be well illustrated, with six to eight articles plus smaller features, and will be a permanent record of all that matters in the Territory. Ordinary members of the Society (subscription 15*s*. a year) will receive the *Journal* free and will, in addition, have the privilege of borrowing books from the extensive Rhodes–Livingstone Museum Library, and of attending meetings and discussions of the Society which will be held in the main towns. Associate membership (5*s*. a year) covers use of the Library for reference only and attendance at meetings. Further particulars can be obtained from the Secretary, Northern Rhodesia Society, Rhodes–Livingstone Museum, Livingstone, Northern Rhodesia.

Care of Archæological Sites

AN article in the *South African Archæological Bulletin* (5, No. 18; June 1950) makes sad reading. At Saulspoort, in the Bethlehem district, rock-shelter paintings occur and an important 'gisement' was identified. It is always of great interest to attempt to correlate the parietal art with datable deposits at the same site. The work of excavation was begun; but during a period of the workers' absence intruders arrived who just 'hogged' the site and left a yawning pit where the section should have been. The problem of controls is a difficult one. Too rigid rules defeat their own object. It is, in a subtle way, the general interest in archæology among all classes that makes the subject live and enables the few professionals to continue the study. Without this general interest the subject would in practice wither. A certain freedom to explore must therefore be given to the amateur; but, of course, stories such as this one are major tragedies. Perhaps the problem could best be tackled through the schools. If the young folk were taught to realize that Stone Age sites are not innumerable and should be respected, that 'hogging' sites is a crime and that excavations should only be attempted either under a competent excavator or after having already had experience in digging, then such grievous happenings as occurred at Saulspoort would no longer occur.

Nomenclature of Viruses

AT the plenary session on August 24 of the Fifth International Congress of Microbiology at Rio de Janeiro (see p. 730), it was recommended that consideration of the starting date for scientific nomenclature of viruses be deferred to the next Congress. Further, the Judicial Commission of the Congress was of opinion that until studies on viruses now in progress have advanced further, the use of any comprehensive system of scientific nomenclature for them is unwise. The co-operation of all virologists is requested in assisting the sub-committee now studying the nomenclature and classification of viruses. The object of these resolutions is to encourage study of the taxonomy and nomenclature of viruses, but to discourage use at the present time of what are considered premature attempts to create comprehensive systems of classification and nomenclature. The chairman of the Virus Sub-Committee of the International Nomenclature Committee is Dr. C. H. Andrewes, National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7.

New Type of Mechanical Gear

A MECHANICAL gear which may be useful in scientific instrument design has been invented by Mr. J. J. Gerritsen, chief engineer of Tiltman Langley Laboratories, Ltd., Redhill, Surrey, which is now developing units based on this invention. The Gerritsen gear consists of a ball race in which the cage and rollers are used as the spider and planet wheels of an epicyclic gear. The races are conical, and by moving them axially the gear ratio may be varied; the centrifugal force on the balls can be used for adjusting the axial position automatically in such a way that the output shaft rotates at a constant speed, while there can be considerable variation of the input shaft speed. It is claimed that the operation of this governing mechanism is extremely rapid, so that the output shaft is little affected even by sudden changes of speed of the input shaft. All the parts of the gear can be easily made. The limiting factor in its performance is presumably the stress at the ball contacts, these points being required to carry tangential load in addition to the normal forces which are found in ball races.

Rheola Forest, Wales

WALES was a beacon to holiday-makers long before the advent of the motor-car. It had, and has, in parts one serious drawback, the dumps of coal-pit refuse, and, less ugly perhaps, the small rough pyramids of

refuse from the slate quarrying. The Rheola Forest in the Vale of Neath is a typical example of the type of afforestation work which is now taking place in the former type of industry. The name Rheola Forest comes from the estate of Rheola, near Resolven, lands from that estate forming the nucleus of the large area of 13,000 acres which now forms the Forest. Planting was commenced there by the Forestry Commission in 1922, and the oldest of the plantations are yielding substantial quantities of pit-props for the coal-fields in the Vale. "The green mantle of foliage," as the writer of the pamphlet, "Britain's Forests—Rheola" (Forestry Commission. Pp. 18. (London: H.M. Stationery Office, 1950. 6*d*. net), picturesquely puts it, "spreading across both sides of this industrial valley provides a welcome contrast to the bare hill-sides with dumps of coal-pit refuse." A start has also been made with planting up the old abandoned pit dumps and thus removing a real eyesore to any countryside. A successful planting of this nature with Scots pine on the old Trafalgar coal-pit dump in the Forest of Dean has changed that blot into a round green hill.

Mixed Commission on Radiobiology

THE Mixed Commission on Radiobiology of the International Council of Scientific Unions held its first meeting on July 16 in the Library of the Pasteur Pavilion of the Institut de Radium, Paris. Those present were Dr. L. H. Gray, Dr. G. Failla, Prof. G. Hevesy, Mme. I. Joliot-Curie, Prof. A. Lacassagne, Dr. L. D. Marinelli, Dr. Melander, Dr. R. Naidu and Dr. P. Bonét-Maury. The International Council of Scientific Unions was represented by Dr. Fraser, and the United Nations Educational, Scientific and Cultural Organisation, through the financial aid of which the meeting was possible, by Dr. Wang. Prof. Hevesy was elected president of the Commission, and Dr. Bonét-Maury secretary. The work of the Commission is concerned principally with the organisation of radiology, from the point of view of both research and of teaching, and the main topics discussed were: the project of an international institute of radiology; the publication of radiobiological work and a bibliography of such work; the definition and measurement of sensitivity to radiation; and the possibility of the exchange of standard biological material. It was decided to create a sub-commission which will study the first and third of the above-mentioned topics.

Australian Journal of Marine and Freshwater Research

THE Commonwealth Scientific and Industrial Research Organization has decided to launch a new scientific periodical, the *Australian Journal of Marine and Freshwater Research* (1, No. 1, April; pp. 154; from the Secretary, C.S.I.R.O., 314 Albert Street, East Melbourne, C.2, 1950; 7*s*. 6*d*.), which will be a medium for the publication of research papers on the results of original investigations on sea, estuarine and freshwater fisheries and cognate subjects. Dr. N. S. Noble, of the Organization's staff, has been appointed editor. He will have the help of an editorial advisory committee in scrutinizing manuscripts submitted for publication, and this committee has as its members Mr. G. Humphrey (Department of Biochemistry, University of Sydney), Prof. P. D. F. Murray (Department of Zoology, University of Sydney) and Dr. H. Thompson (chief, C.S.I.R.O. Division of Fisheries). The *Journal* will not be issued at set periods, but as the accumulation of suitable material dictates. It is at present anticipated that two issues will be published in each year. The first number has just appeared and contains papers on the Australian anchovy, underwater fouling, the barracuta fishery in Australian waters, bacteriology of shark spoilage and the setting of Sydney rock oysters.

Journal of the Royal Technical College, Glasgow

PUBLICATION of the *Journal of the Royal Technical College, Glasgow*, which was suspended during the War, has now been resumed, and the first post-war number to appear (5, Part 1, January 1950) contains twenty-six research papers contributed by members of the staff and senior students of the College. A list of other publications by members of the College is included; but only the titles of the periodicals in which the articles appear, and not the full references, are given. In one of the papers, T. S. Wylie describes experiments which show that cavitation can occur in a liquid irradiated with sound of frequency 3,780 c.s. An oscillator consisting of a nickel tube made to vibrate by magnetostriction at audio frequencies was used, and the form of the cavitation produced in water at the frequency of 3,780 c.s. was examined. Evidence was obtained that the rate of erosion on a metal surface in contact with a field of cavitation varies, at constant temperature, with some power of the time greater than unity. Several of the papers in the *Journal* deal with problems of a chemical nature; and, on the metallurgical side, blast-furnace reactions, the reactions of sulphur in steel-making, the sintering of iron ores, thermal changes in fireclay and kaolinite, and the surface tension of molten silicates form the subjects of individual articles. The publication concludes with a number of papers dealing with problems in structural engineering and shipbuilding.

Ministry of Agriculture and Fisheries: Postgraduate Scholarship Awards

THE Ministry of Agriculture and Fisheries has awarded the following postgraduate research and training scholarships, which are tenable for periods up to three years in the first instance at the university or institute shown: *Agricultural economics*, G. H. Brayshaw, G. B. Clarke and Miss C. O'Loughlin (Cambridge), J. T. Creighton, T. C. Haddow and Miss C. Scott (Oxford), and D. T. Edwards (Reading); *Agricultural engineering*, P. Hebblethwaite (Michigan State College), E. W. Hughes (Reading), and R. E. James-Robertson, J. N. Merridew and G. B. Shipway (King's College, Newcastle); *Husbandry*, H. K. Baker, R. W. E. Ball and D. R. Hodgson (Cambridge), C. W. Bramley (Leeds), J. Alston, J. Cook, A. J. Cooper, T. L. Crocker, C. G. Guttridge, L. A. Mantle and J. J. North (Reading), Miss J. C. Whitaker (Wye College, London), and C. E. Wright (Queen's University, Belfast); *Agricultural statistics*, Miss E. M. Davis and J. K. R. Wood (Rothamsted Experimental Station), J. A. Evans (Oxford), and A. F. Purser (Edinburgh).

Foreign Scholarships for British Students

A NUMBER of foreign governments and universities are offering scholarships to British students. In most cases the awards are for 4–12 months of post-graduate study at a university; but the Italian Government also offers scholarships to authors, artists, musicians and others for study or travel in Italy. Scholarships for 1950–51 have recently been

announced; the countries and the number of awards are as follows: Austria (3), Belgium (8), Denmark (3), Finland (1), France (4), Germany (4), Italy (3), The Netherlands (6), Norway (4), Persia (1), Spain (1), Sweden (4) and Switzerland (1). Awards by the Government of Brazil will be announced shortly. These scholarships by foreign countries correspond to those awarded by the British Council to foreign graduates for studying at universities in the United Kingdom. Further details about these schemes can be obtained from the British Council, 65 Davies Street, London, W.1.

Sectional Meeting in New Delhi of the World Power Conference

THE second post-war sectional meeting of the World Power Conference will be held in New Delhi during January 10–15, 1951. At the same time, the World Power Conference International Commission on Large Dams will hold its fourth congress, and the International Commission on Irrigation and Canals its first plenary session. During January–February an Indian international engineering exhibition will be open in New Delhi. The theme of the sectional meeting is the "Utilization of Power in its Various Aspects", and this will be considered under two headings: utilization of electricity in agriculture; and the co-ordination of the development of industries and the development of power resources. A set of three study tours (and an alternative set) which between them cover most of the territory of India has been arranged, and on the completion of these tours the closing session of the conference and congress will be in Mysore on February 1. Details of these events are contained in Bulletin No. 2, issued by the Indian National Committee of the World Power Conference. This Bulletin can be obtained from the Secretary, Central Board of Irrigation, Curzon Road Barracks, New Delhi, or from the British National Committee, World Power Conference, 201 Grand Buildings, Trafalgar Square, London, W.C.2.

Royal Society of Edinburgh: Officers for 1950–51

AT the annual statutory meeting of the Royal Society of Edinburgh, held on October 23, 1950, the following officers and members of council were elected: *President*, Prof. James Kendall; *Vice-Presidents*, Prof. A. C. Aitken, Prof. E. P. Cathcart, Sir Alexander Gray, Prof. Arthur Holmes, Prof. W. O. Kermack and Prof. E. T. Copson; *General Secretary*, Dr. J. E. Richey; *Secretaries to Ordinary Meetings*, Prof. J. Norman Davidson and Dr. John E. MacKenzie; *Treasurer*, Mr. A. W. Young; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Councillors*, Mr. E. G. Dymond, Prof. R. W. Wheldon, Prof. T. Neville George, Prof. J. W. Heslop Harrison, Dr. C. E. Lucas, Prof. M. G. Say, Prof. W. M. Smart, Prof. J. F. Allen, Prof. A. Murray Drennan, Dr. E. Wyllie Fenton, Mr. J. M. Ross and Prof. C. M. Yonge.

The Night Sky in November

NEW moon occurs on Nov. 9d. 23h. 25m., U.T., and full moon on Nov. 24d. 15h. 14m. The following conjunctions with the moon take place: Nov. 6d. 19h., Saturn 2° N.; Nov. 13d. 04h., Mars 4° N.; Nov. 16d. 23h., Jupiter 1° N. Mercury, in superior conjunction on November 1, is too close to the sun for favourable observation during the month. Venus, in superior conjunction on November 13, is unfavourably placed for observation during most of the month. Mars is an evening star and sets more than two hours after the sun during November; its declination is more than 24° S. and, as it lies rather low even at meridian passage in the British Isles, it is not well placed for observation. Jupiter, in the constellation of Aquarius, sets at 0h. 10m., 23h. 20m. and 22h. 30m. on November 1, 15 and 30, respectively, and is well placed for observation. Saturn, in the constellation of Virgo, is a morning star, rising at 3h., 2h. 15m. and 1h. 25m. at the beginning, middle and end of the month, respectively. Occultations of stars brighter than magnitude 6 are as follows: Nov. 6d. 4h. 47·6m., 89 Leon. (*R*); Nov. 20d. 20h. 46·0m., ε Pisc. (*D*); Nov. 26d. 18h. 23·3m., 136 Taur. (*D*); Nov. 26d. 19h. 05·2m., 136 Taur. (*R*); Nov. 30d. 0h. 39·0m., γ Canc. (*R*). *R* and *D* refer to reappearance and disappearance, respectively, and the latitude of Greenwich is assumed.

Announcements

SIR LEWIS FERMOR has been elected president for the session 1951–52 of the Institution of Mining and Metallurgy. Sir Lewis served with the Geological Survey of India from 1902 until his retirement as director in 1935. He has since been engaged in consulting work in India, Malaya and Africa.

THE Council of the Royal Society of Edinburgh has awarded the David Anderson-Berry Prize for 1950, posthumously, to Dr. D. E. Lea, for his book "The Actions of Radiations on Living Cells".

THE Melchett Medal for 1950 of the Institute of Fuel has been awarded to Prof. R. J. Sarjant, professor of fuel technology in the University of Sheffield. The Medal was established and endowed by the founder-president of the Institute, the late Lord Melchett of Landford, and is awarded from time to time for outstanding work in research, administration, construction or any other professional activity involving the scientific preparation or use of fuel. There have to date been six overseas recipients, and Prof. Sarjant is the fourteenth British holder of the award.

MR. G. M. MICHIE has joined the Research and Development Division of the British Steel Founders' Association in a senior executive capacity. Mr. Michie, who for the past two years has been senior research metallurgist in charge of the research laboratories at Penistone of Messrs. David Brown and Sons (Huddersfield), Ltd., is known for his work on the development and application of non-destructive testing of steel castings.

THE Institution of Naval Architects has made the following awards: Froude Research Scholarship in Naval Architecture (1950), of £500 a year for two years, to R. L. Townsin, of King's College, Newcastle upon Tyne; Sir William White Postgraduate Scholarship in Naval Architecture (1948), of £150 a year, to D. I. Moor, of Messrs. William Denny and Bros., Dumbarton, for one further year; Parsons Scholarship in Marine Engineering (1950), of £175 a year, to G. M. Jordan, of Messrs. Alfred Holt and Co., Liverpool, for three years at the University of Liverpool; Yarrow Scholarship in Marine Engineering (1950), of £175 a year, to A. W. Bolwell, of Messrs. Yarrow and Co., Scotstoun, Glasgow, for four years at the University of Glasgow.

DYNAMICS OF INDUSTRIAL LOCATION

INTEREST in problems of industrial location was greatly stimulated in Great Britain in the years between the two World Wars by the declining prosperity of many long-established industries and the severe incidence of unemployment in those regions where these industries were located. At the same time, the relative prosperity of southern England and the Midlands where the newer industries were rapidly expanding led many persons to question the desirability of allowing industrialists unrestricted freedom to set up their factories where they willed without reference to the social costs involved in heavy localized unemployment and the loss of capital assets represented by local government services, buildings, roads, railways and other capital assets which were likely to become redundant, or only partially utilized, because of the transference of people from these older industrial areas to areas where new buildings, transport facilities and public utility services would have to be provided. It was suggested that the jobs should be brought to the workers rather than that workers should be brought to new jobs in new industrial areas. On the other hand, it was pointed out that, in the long run, industrial efficiency and the power to compete in export markets would be reduced if artificial regulation of industrial location resulted in industry being forced to settle in areas where the net economic advantages were less than those enjoyed when full freedom of choice was permitted. Location, it was stressed, is a dynamic and not a static problem, and that historically there have been many shifts in the industrial centres of gravity.

Obviously, before any reconciliation can be effected between these opposing points of view, the necessary prerequisite is a knowledge of the facts. What are the factors which determine the choice of location for a factory or other industrial plant, and how can we measure and compare the net advantages, both economic and social, of different localities ? The need for greater knowledge was stressed by Dr. H. S. Phillips in a paper entitled "Some Factors determining the Movement of Industry—1934–1950", read before Section F (Economics) at the recent meeting in Birmingham of the British Association for the Advancement of Science. Dr. Phillips emphasized that anything which improves knowledge of location matters will help to increase both the social benefit and private profit to be derived from improved location decisions, and will provide a basis on which the difference between private and community location interests can be bridged. Had location knowledge and ideas been as widely appreciated and disseminated in the inter-war years, or the relevant statistics been as readily available as they are now coming to be, many industries which settled in areas which ultimately became overcrowded would have been attracted to the Development Areas twenty years ago with equal or greater success and with a vast interim saving to the community in terms of unemployment and strategic liability.

In his survey of the factors determining movements in industry during 1934–50, Dr. Phillips divides the fifteen years into four main periods. The first (1934–38) was one in which, despite the initial activities of the Special Areas Commissioners, there was complete freedom for industrialists to establish their factories in any part of the country. Many of the factories built in this period were concerned with the production of consumer goods such as electrical equipment, radios or plastic articles, and they were largely attracted to cities such as London and Birmingham, where large markets were on their doorsteps ; this was a continuation of a trend which had manifested itself since 1920. There was also a peripheral spread of industry in London to districts where labour was more readily available than in the centre and where costs were lower. This, however, was a trend which was noticeable even before 1914, for example, in printing, and which has continued up to the present day, for example, in clothing. The second period (1939–45) was one in which location was affected by concentration of non-essential firms, by the 'Blitz' and by the strategic building policy which had started before the War with the shadow-factory programme. Many large government factories were built in areas which would probably never otherwise have obtained such buildings.

The third period lasted from 1945 to about the middle of 1948. It was radically different from the other periods in that strong conscious efforts were made, following the passing into law of the Distribution of Industry Act, 1945, to prevent further industrial development in the South and the Midlands. The policy was largely operated through a procedure which made the granting of building licences largely dependent on prior approval of the scheme on location grounds. During this period, difficulties of labour supply and site shortages in the South and Midlands helped to drive considerable numbers of firms to the North and to Wales. New firms were encouraged to go to the Development Areas by attractions such as government factories, raw material allocations, assistance in the purchase of sites, provision of houses for key workers and the laying-on of gas, water and electricity.

In the fourth period (mid-1948 onwards), Dr. Phillips considers that the location factors operating may approach more closely to the pre-war pattern, unless they are consciously prevented from doing so. The availability of labour in the years to come will, he considers, give the Development Areas a very real attractive power. Firms, however, are now more conscious of costs than in the early post-war years, and they are reluctant to face the considerable capital expense involved in transferring production to a new locality. They have also become more concerned about the unknown cost elements of a new location. Dr. Phillips considers that there is evidence in recent experience for assuming that production costs at different locations in such a relatively small country as Great Britain differ much less than is generally assumed between comparable production units. There is probably much to be said for this view in connexion with light industries, especially as a result of the development of road transport and the telephone service during the past twenty years or so. On the other hand, the increase in transport costs which is now taking place may have to some extent a restrictive effect on choice of location.

During the post-war period the availability of labour has been the vital location factor favouring the older industrial areas. Pre-war unemployment

was substantial even in relatively prosperous areas, and workers could be found without the need of offering enhanced wages. This factor has been strengthened by the fact that whereas sites for both housing and industry have been scarce and subject to strict control on planning grounds in the South and Midlands, there has been a special drive for sites in central Scotland, Wales, Tyneside and Merseyside as part of a positive plan to encourage the settlement of industry.

THEORY OF SORPTION COLUMNS

The Ψ Conditions : Two Types of Non-Equilibrium Fronts

A PROCESS in a sorption column can be described completely by giving for each molecular species A_i its concentrations c_i and q_i as functions of x (the amount of sorbent in cm. or gm. between the layer x and the inlet end) and V (the volume of solution that has passed the layer x). For an *equilibrium* process, c_i and q_i are functions of a single variable,

$$\Psi = V/x, \tag{1}$$

when the boundary conditions contain only Ψ (uniform composition of the initial sorbent at $\Psi = 0$ ($V = 0$), and uniform composition of the entering solution at $\Psi = \infty$ ($x = 0$)) and not V or x separately. For most practically important cases, this condition is valid or can be made valid by a suitable change in the co-ordinates.

An approach essentially equivalent to this 'Ψ condition' has already been used by Offord and Weiss[1] for some special cases. A great simplification can be gained by a consistent use of it. When the Ψ condition applies, the conservation law requires that, for all continuous regions,

$$\begin{aligned} &\text{either } c_i = \text{const.} \\ &\text{or } dq_i/dc_i = \Psi \text{ (diffuse front).} \end{aligned} \tag{2}$$

Finally, for the discontinuities (sharp fronts),

$$\Delta q_i/\Delta c_i = \Psi_s. \tag{3}$$

In a paper to be published in the *Arkiv för Kemi*, these equations will be applied to a number of important cases, such as frontal analysis and displacement analysis. Especially in connexion with V—x diagrams, this approach will be shown to give a uniform, quick and simple way of treating and understanding the processes.

For ion exchangers it is advantageous to use instead the fractions of the various ions in solution and sorbent:

$$\alpha_i = \frac{q_i}{s_0}, \beta_i = \frac{c_i}{a_0}, \text{ where } s_0 = \Sigma q_i, a_0 = \Sigma c_i, \tag{4}$$

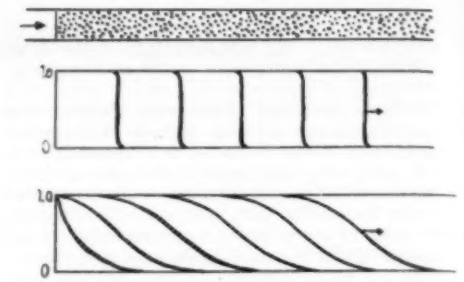
and to replace Ψ by the proportional quantity

$$\psi = a_0 V/s_0 x. \tag{5}$$

We then find

$$\begin{aligned} d\beta_i/d\alpha_i &= \psi \text{ for continuous fronts,} \\ \Delta\beta_i/\Delta\alpha_i &= \psi_s \text{ for sharp fronts.} \end{aligned} \tag{6}$$

Non-equilibrium processes in sorption columns are best treated by first considering the corresponding equilibrium process. With increasing V and x, the curves c_i (Ψ) and q_i (Ψ) will approach indefinitely to the equilibrium curves.



(*a*) Sorbent layer ; (*b*) sharp front of constant form (advancing); (*c*) broader front of constant form (advancing); (*d*) broadening front (retiring). In *b*–*d*, the abscissa is the length of the column, the ordinate is c/c_0, where c is the concentration of A in the solution. The curves refer to different times (or values of V)

Where a sharp front would have been formed at equilibrium, a *final form front* is obtained for non-equilibrium. The front eventually moves through the column with a constant form and a constant velocity. Then q_i and c_i are functions of the single variable

$$z = x - V\Psi_s^{-1}, \tag{7}$$

which is the distance from the position the sharp front would have had at equilibrium. Moreover, for each substance,

$$\frac{q_i - q'_i}{c_i - c'_i} = \frac{q''_i - q'_i}{c''_i - c'_i} = \Psi_s, \tag{8}$$

which means that the point q_i, c_i is on the straight line connecting the points q_i'', c_i'' and q_i', c_i', valid far behind and far ahead of the front.

So far as I know, the first attempts at a general treatment of final form fronts were made by Johansson, Persson and Svensson[2], and Sillén[3].

If the sorption process follows Langmuir kinetics, the following formulæ can be derived for the sorption of one sorbate on an initially empty sorbent :

$$\frac{q}{q''} = \frac{c}{c''} = \frac{1}{1+Z}; \; Z = \exp kq''z, \tag{9}$$

and for the sorption of an ion in an ion exchanger, which is initially saturated with a less sorbable ion,

$$\beta = \alpha = \frac{1}{1+Z}; \; Z = \exp(k - k_1)s_0 z. \tag{10}$$

In these equations, k and k_1 are the kinetic constants.

If a Tiselius displacement analysis is carried out under non-equilibrium conditions, the various substances will finally arrange themselves in front of the displacing substance A_N (in the bulk of which q''_N and c''_N are valid) in the order of decreasing sorbability, just as in the equilibrium case. The fronts will no longer be sharp, but each substance will form a diffuse 'head' and a diffuse 'tail', both of constant form. However, for each substance, the following expression still holds :

$$\frac{q_i}{c_i} = \Psi_s = \frac{q''_N}{c''_N}. \tag{11}$$

This is Tiselius's equation[4], which is thus valid for the non-equilibrium displacement.

The other type of front is the *broadening front*; the best theoretical approach to its form is probably by using the condition that $c_i(\Psi)$ and $q_i(\Psi)$ approach the curves for equilibrium for increasing V and x. Sometimes 'false isotherms' may prove useful (see the following communication).

Several treatments in the literature of non-equilibrium processes in sorption columns are based on assumptions, such as formal analogy to heat transfer, which would lead to a linear isotherm. It is true that a linear isotherm may sometimes be a useful approximation in partition chromatography. However, so far as ordinary sorption processes are concerned, the focusing of attention on linear isotherms seems to be unfortunate. A linear isotherm is a singular case; it would give fronts showing the characteristics of neither of the two immensely more important groups of fronts, the final form fronts, and the broadening fronts. With a linear isotherm, no final form front is obtained; the fronts will broaden, but to a less extent than normal broadening fronts, so that the curves $c_i(\Psi)$ and $q_i(\Psi)$ finally approximate to vertical lines and not to continuous curves. The results calculated for a linear isotherm will thus disagree with what is observed in almost all types of experimental sorption or desorption runs.

LARS GUNNAR SILLÉN

[1] Offord, A. C., and Weiss, J., Faraday discussion, Reading, Sept. 1949 (in the press).
[2] Johansson, C. H., Persson, G., and Svensson, B. (1948). IVA, No. 200. The work was concluded in 1942, the manuscript prepared in 1945.
[3] Sillén, L. G., *Arkiv Kemi*, **22A**, No. 15 (1946).
[4] Tiselius, A., *Arkiv Kemi*, **16A**, No. 18 (1943).
[5] For example, Boyd, G. E., Myers, L. S., and Adamson, A. W., *J. Amer. Chem. Soc.*, **69**, 2849 (1947).

Kinetics and Equilibria of Ion Exchange

ALTHOUGH a great amount of work has been performed on the kinetics and equilibria of ion exchange, they have not hitherto been well understood, or successful empirical formulæ worked out.

A few years ago, two of us began studying the exchange of silver and hydrogen ions on different ion exchangers[1]. The chief reason for this choice was that even very low concentrations of silver ion can be measured accurately and quickly by means of silver electrodes.

Silver ions are more strongly adsorbed than hydrogen ions by the ion exchangers studied by us. If an ion exchanger is originally saturated with hydrogen ion (thus in the form HR), and silver ions are passed through, it can be expected[2] that the 'silver front' will quickly approach a final shape, and then move on with *constant form* and constant velocity through the ion exchanger column. This was indeed found to be the case[1]. This result, however, is at variance with formulæ analogous to those for heat transfer which would correspond to a linear sorption isotherm, and which demand that the front will in any event broaden indefinitely with increasing column-length and time[3].

Our first working hypothesis was that the process in the ion exchanger can be treated as a bimolecular reaction:

$$\underset{\alpha a_0}{Ag^+} + \underset{(1-\beta)s_0}{HR} \underset{k_1}{\overset{k}{\rightleftharpoons}} \underset{(1-\alpha)a_0}{H^+} + \underset{\beta s_0}{AgR} \qquad (1)$$

With this assumption we were able to derive a rather simple formula (= (10) in preceding paper):

$$\alpha = \beta\,;\ \log\left(\frac{1-\alpha}{\alpha}\right) = k'(t_0 - t)\,; \qquad (2)$$

$$k' = (k-k_1)\,a_0 \log e\,;\ t_0 = \frac{s_0 + a_0}{a_0 v}\,.\,x. \qquad (3)$$

Here a_0 and s_0 refer to the concentrations per unit volume of sorbent column, t is the time, v the velocity of flow, x the length of column, α and β are defined by (1), and k' and t_0 are derived constants defined by (3). The formula (2) proved to describe very well a large number of runs made each at a constant v; k' proved to be proportional to $\sqrt{v}$ [1].

During the War, Nachod and Wood[4], Thomas[5], and Walter[6] independently assumed a bimolecular mechanism for the ion exchange process. Thomas derived a rather complicated solution of the differential equations for the general case, and Hiester and Vermeulen[7] showed an ingenious way of making practical calculations with Thomas's equations by means of diagrams of suitable auxiliary functions. However, if the added ion is more strongly sorbed, the 'leaking curve' so quickly approaches our formula (2) that it may perhaps be unnecessary for most practical purposes to use more elaborate expressions.

We have also been studying the opposite phenomenon, where an ion exchanger, saturated with silver ion, is percolated with a solution containing hydrogen ions. We were able to measure the amount of silver ion leaking out accurately down to $\alpha = 10^{-3}$. The results, especially for lower values of α, certainly cannot be reconciled with any formula assuming the same bimolecular constants of k and k_1 as were found in the first-mentioned experiments, or with any other set of constants k and k_1.

That this must be so became evident from equilibrium measurements. If k and k_1 were constant, the 'mass-action law constant'

$$K = \frac{\beta(1-\alpha)}{\alpha(1-\beta)} \qquad (4)$$

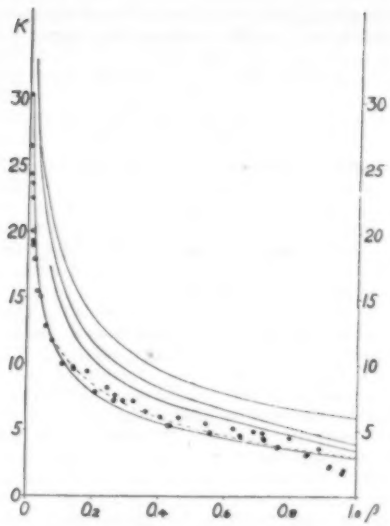
should be constant: $K = kk_1^{-1}$. For real ion exchangers, the apparent K, however, varies greatly with β. In the accompanying graph the black dots are static measurements of $K(\beta)$ with the ion exchanger 'Wofatit KS'; K is seen to vary from values around 3 for $\beta \approx 1$ (almost only AgR) to around 30 for low β (almost only HR). For 'Dowex 50', a curve with a minimum was obtained.

One might suggest that the ion exchanger contains a number of different types of sites, each with its individual K. However, no such explanation would explain the curve with a minimum in $K(\beta)$.

Whatever the explanation may be, there seems to be no foundation for the use of constants k and k_1 in (1), at least for the broadening type of front. For the constant form front, it still seems to give a very good approximation.

Since this kinetical approach did not seem very promising, we instead tried an approximate assumption that, in our elution experiments, equilibrium had at all points been attained between sorbent and solution. To our measurements of the silver fraction α in the effluent solution at various times we applied the equation:

$$\beta = 1 - \int_{\alpha}^{1} \psi\, d\alpha. \qquad (5)$$



Apparent equilibrium constant K of ion exchange $Ag^+ + HR \rightleftarrows H^+ + AgR$ as function of β, the 'silver fraction' in the ion exchanger. Black dots: static measurements. Curves: calculated from elution experiments by means of formula (5). From above, velocities: 70, 18, 9, 2, 1 ml./min. The two latter curves almost coincide; that for 2 ml./min. is dotted.

The results from a number of runs at different velocities of flow are plotted in the graph. They are not given in the usual isotherm form, β *versus* α, since this mode of representation would crowd the curves and points too much together. We have preferred to give the apparent equilibrium constant K as a function of β, the silver fraction in the ion exchanger, since this type of diagram is much more sensitive to small differences; of course, the experimental errors also show up much more. The curves for the velocities 70, 18 and 9 ml./min. are higher than the values obtained at static equilibrium runs, but the curves are seen to approach to the static values with decreasing velocity of flow. For the lowest two velocities, 2 and 1 ml./min., the curves from the elution experiments lie amid the static points; actually the curve for 2 ml./min. is sometimes a little bit lower than that for 1 ml./min., which may be ascribed to experimental errors.

From the graph we would like to draw two conclusions. First, at the lowest velocities of flow the approach to equilibrium seems to be so good that the adsorption isotherm or the equivalent $K(\beta)$ can be obtained from dynamic experiments with the aid of formula (5) with no less accuracy than from static measurements. The dynamic experiments, of course, are much less laborious than the static ones. The runs at the lowest two velocities, each of which gave us a complete curve $K(\beta)$, took 28 and 32 hr. respectively. The work was much aided by automatic recording devices, so there was no need for watching the apparatus all the time. The calculations according to (5) took something like ten hours. On the other hand, to obtain all the points marked in the graph from static experiments, more than three months work was needed, representing something like six hundred hours work. If in the future we wish to determine equilibria of ion exchange, we shall probably prefer to do it by the dynamic method. In many cases where potentiometric methods cannot be applied, optical or conductometric methods may be suitable.

Secondly, although the upper curves in the graph certainly do not represent equilibrium states, the curves of the apparent $K(\beta)$ are a very compact way of representing the whole course of the elution curve. It occurs to us that in the case of spreading fronts, even if equilibrium is actually not reached, a very useful approximation to the elution curve could be obtained by using 'false isotherms' or false $K(\beta)$ curves like the upper ones in the graph.

A more detailed account of this work will be given elsewhere.

Note added in proof. The equilibrium quotient in (4), which has been called K in this article, we would now prefer to denote by $\varkappa$ to prevent confusion with the thermodynamic quantity (*Acta Chem. Scand.*, 4, 556; 1950).

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Feb. 20.

[1] Sillén, L. G., and Ekedahl, E., *Arkiv Kemi*, **22A**, No. 16 (1946). Ekedahl, E., and Sillén, L. G., *Arkiv Kemi*, **25A**, No. 4 (1947).
[2] Sillén, L. G., *Arkiv Kemi*, **22A**, No. 15 (1946); see also preceding communication.
[3] Boyd, G. E., Myers, jun., L. S., and Adamson, A. W., *J. Amer. Chem. Soc.*, **69**, 2849 (1947).
[4] Nachod, F. C., and Wood, W., *J. Amer. Chem. Soc.*, **66**, 1380 (1944); **67**, 629 (1945).
[5] Thomas, H. C., *J. Amer. Chem. Soc.*, **66**, 1664 (1944).
[6] Walter, J. E., *J. Chem. Phys.*, **13**, 332 (1945).
[7] Hiester, N. K., and Vermeulen, T., *J. Chem. Phys.*, **16**, 1087 (1948).

PHOTONS AND WAVES*

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THE dual nature of light manifests itself most strikingly in Einstein's equation[1] for the mean square fluctuation of radiant energy in thermal equilibrium

$$\overline{\delta\varepsilon_T^2} = \overline{(\varepsilon_T - \bar{\varepsilon}_T)^2} = h\nu\bar{\varepsilon}_T + \bar{\varepsilon}_T^2, \qquad (1)$$

where ε is the energy in the system considered, per unit frequency-interval at some frequency ν; the suffix T relates to thermal equilibrium; bars over the symbols stand, as usual, for mean values. It is well known that the second term on the right-hand side can be interpreted as resulting from the interference of the *waves* by which the energy is represented classically, while the first term is the same as if the energy were concentrated in $\bar{N}_T$ *photons*, $\bar{\varepsilon}_T = h\nu\bar{N}_T$, the number of which fluctuates by the same law as if they were independent particles.

Einstein's equation is fundamental also for the theory of electrical communications. Whether wires are used in the transmission or not, by Maxwell's

* Abstract of some parts of a lecture entitled "La Théorie des Communications et la Physique" in a series of lectures on communication theory organised by M. Louis de Broglie, delivered in Paris on May 9.

theory the energy is always transmitted through empty space, that is, by radiation; hence equation (1) is the physical basis of thermal noise in electrical communication systems. But noise is the fundamental physical limitation of any communication channel in transmitting information; hence ultimately it sets also the limit to what we can learn quantitatively about physical phenomena.

Equation (1) shows clearly two sources of noise: one arising from the indefiniteness connected with the concept of temperature, the other from the finite size of quanta. A third source arises in the interaction of radiation with matter from the finite size of the elementary electric charge. Between them these three sources of noise or uncertainty set the limits by which we can empirically define concepts such as 'waves' or 'photons'. It is generally believed that these two methods of description become equivalent at very great quantum numbers. It will be shown that though this is approximately true, the classical method is always slightly inferior to the quantum description as regards *quantitative information content*.

In communication problems, it is convenient to take as the unit of discussion the 'information cell', with a frequency width $\Delta\nu$ and a time interval Δt, so that

$$\Delta\nu\ \Delta t = 1. \qquad (2)$$

It has been shown[2] that each information cell can be associated in various ways with two degrees of freedom, one of which is an amplitude, the other a phase. One way of describing a signal is to associate a Planck oscillator with every information cell, and to specify its state. In this article, from here onwards, ε and N will relate to the energy and photon content of *one* information cell. If there is no signal present, and the whole communication system is at a temperature T, we have, by Planck's formulæ,

$$\bar{\varepsilon}_T = h\nu \Big/ \left(\exp\frac{h\nu}{k\bar{T}} - 1\right), \quad \overline{N}_T = 1 \Big/ \left(\exp\frac{h\nu}{k\bar{T}} - 1\right) \qquad (3)$$

If there is a signal, so that the mean energy $\bar{\varepsilon}$ exceeds $\bar{\varepsilon}_T$, one deduces, by exactly the same arguments which led Einstein to equation (1):

$$\begin{aligned} \overline{\delta\varepsilon^2} &= \varepsilon(h\nu + 2\bar{\varepsilon}_T) - \varepsilon_T^2, \\ \overline{\delta N^2} &= \overline{N}(1 + 2N_T) - \overline{N}_T^2. \end{aligned} \qquad (4)$$

The second formula gives the fluctuation of the photon number N in the cell.

We can use this formula for constructing a scale or 'ladder' of distinguishable signals, making each step of the ladder equal to the root mean square fluctuation at that level. With this convention, and neglecting the last term in equation (4), which becomes unimportant at appreciable signal-levels, we find that below a level N_m we can distinguish the following number S of steps:

$$S = \int_{N_T}^{N_m} \frac{dN}{\overline{(\delta N^2)}^{1/2}} = \frac{2N_m^{1/2}}{(1 + 2\overline{N}_T)^{1/2}}. \qquad (5)$$

The state of the cell cannot be specified closer than to the nearest rung. It may be noted that S increases not with N but with its square root. Using the S- or $N^{1/2}$-scale, we can describe completely any signal, as illustrated in Fig. 1, by associating an integer with every cell, giving the position of the signal on the ladder.

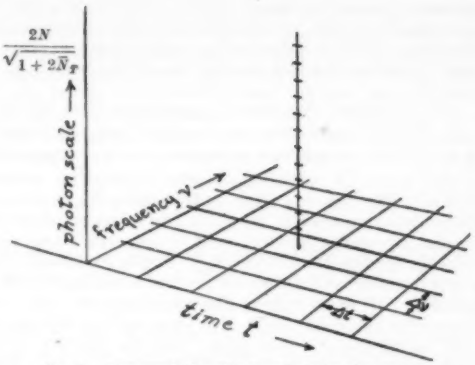

Fig. 1. Representation of a signal on the photon scale

Comparing this with the classical method of description[3] in which every cell had *two* data associated with it, an amplitude and a phase, it might appear that we have lost one degree of freedom. We have now only one datum, of the nature of an amplitude, but no phase. Yet by the quantum method of description we have gained rather than lost information. We shall show that if we carry out the classical type of analysis with a suitable device, associating S_1 steps with the amplitude of the signal, and S_2 steps with its phase, the product $S_1 \times S_2$ will be, in fact, always *smaller* than S.

The first problem is to work out the distinguishable steps in measuring the amplitude of an electric signal, up to a level of $\overline{N}$ photons per cell. In practice, if we want to measure a weak electric signal, we make the field interact with electrons, and amplify the electron current. We choose for the discussion a special model of such a detector and amplifier; but it will be shown that in the case of optimum performance, we reach a limit which is quite independent of any special feature of our model. Thus we may consider the result as more general than the derivation.

Assume that we introduce the signal, which occupies a waveband $\Delta\nu$, into a wave-guide as shown in Fig. 2, and we explore its field by shooting an electron beam across the guide, in the direction of the electric vector. The signal will produce velocity modulation in the electron beam, and this can be translated, by well-known means, into current modulation.

(Quantal energy exchange between electrons and the field in a wave-guide at high quantum numbers has been previously discussed by Lloyd P. Smith[3]; but I cannot agree with most of his results. Monokinetic electrons and exchange of sharply defined quanta on one hand, well-defined

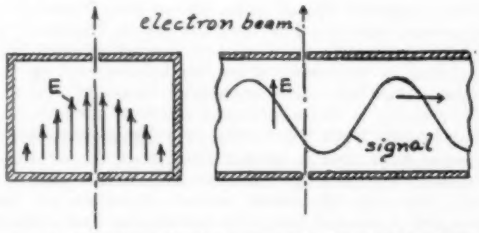

Fig. 2. Exploring a signal in a wave-guide by an electron beam

entrance phases and short transit times on the other, are mutually exclusive phenomena by the uncertainty relation; hence I believe that only certain averages over Smith's detailed results have physical significance.)

Let us adjust the beam current so that in the mean $\overline{M}$ electrons cross the guide during the time $\Delta t = 1/\Delta\nu$ in which one information cell, containing in the mean $\overline{N}$ photons, passes through a cross-section. We can consider as the essential quantity the positive number $\bar{n}$, which is the mean number of quanta, $h\bar{\nu}$, exchanged between the electrons and the photons, irrespective of the sign of the exchange. It is this number which determines the character of the process. If $\bar{n}$ is large, the phenomenon will be essentially classical. Only this case will be discussed here, as amplitude and phase can be defined with some accuracy only in the quasi-classical region. The extension to small $\bar{n}$'s and the detailed calculations will be given elsewhere[4].

On the expectation, which will be confirmed *a posteriori*, that the accurate determination of amplitude and phase requires intense interchange, we try to make $\bar{n}$ at given photon number $\overline{N}$ as large as possible. We can do this, first by slowing down the wave, thus increasing the field intensity, secondly by choosing the most advantageous transit time. But the smallest group velocity which we can allow is the one at which the signal is just cut off at the low-frequency end of the wave-band $\Delta\nu$. The best transit angle relative to the mean frequency $\bar{\nu}$ is found to be 134°. Taking these into account, one obtains for the best possible interchange the relation,

$$\bar{n}^2 = \frac{1{\cdot}5}{137}\left(\frac{v}{c}\right)\left(\frac{\Delta\nu}{\bar{\nu}}\right)^{1/2}\overline{N}. \qquad (6)$$

In this formula, valid for large photon numbers only, all special features of the model have disappeared. v is the velocity of the electrons; c the velocity of light; $137 = hc/2\pi e^2$ is the fundamental number which links electrons to photons. It is evident that the factor of $\overline{N}$ in equation (6) is always very small, though, as will be shown below, in the optimum case it must be made equal to unity. But it is possible, at least in theory, to make the electron pass repeatedly, say P times, through the guide, always in the right phase. (In practice, one would rather replace the wave-guide by a 'high-Q' resonator.) P can be made large, of course, only if the wave-band is very restricted; otherwise one could not fix the mean frequency of the signal beforehand with any reliability. The interesting result follows, that the classical analysis can be carried out with optimum accuracy only if one decomposes the signal from the start into narrow wave-bands—a direct consequence of the smallness of the interaction parameter 1/137.

Assuming now that we can make the coefficient of $\overline{N}$ in equation (6) as large as we like, what is its optimum value? The quantity to be measured is the mean electric amplitude in the information cell, and this is proportional to the square root of the photon number. The measured quantity, on the other hand, is the alternating electron current, and it is known from the theory of velocity-modulation devices that this is proportional to $\bar{n}.\overline{M}$ for weak signals. For the optimum we impose the criterion that the relative mean square deviation of the quantity measured from the quantity to be measured shall be as small as possible, that is,

$$\frac{\overline{(nM - CN^{1/2})^2}}{(n\overline{M})^2} = \text{minimum}. \qquad (7)$$

The most suitable constant C itself is to be determined from the condition

$$\overline{(nM - CN^{1/2})} = 0. \qquad (8)$$

The problem is how to choose $\bar{n}$ and $\overline{M}$, that is, interchange parameter and electron current so as to satisfy the condition (7). We give here only the physical basis of the calculation. Too weak an interchange would leave the cell unexplored. Too strong an interchange, on the other hand, will interfere with the object of measurement, because, though in the mean an electron is as often accelerated as retarded, fluctuations in the number of electrons which pass through accelerating or retarding phases might produce extra photons, which could not be distinguished from those belonging to the signal, or annihilate some. Similarly, too weak a current will produce a large 'shot effect'; too large a current will again spoil the object. It may be noted that we have here a type of uncertainty which springs directly from the fact that photons and electrons are discrete, without any reference to the physical values of h or e. This is confirmed by the calculation, which, assuming 'normal' shot effect and introducing some evident assumptions about the mutual independence of n, M and N, such as $\overline{nM} = \bar{n}.\overline{M}$, gives

$$\frac{\overline{nM - CN^{1/2}}^2}{(n\overline{M})^2} = \frac{1}{4\overline{N}} + \frac{1}{\bar{n}} + \bar{n}\left(\frac{1}{\overline{nM}} + \frac{\overline{nM}}{4\overline{N}^2}\right) \qquad (9)$$

This is a minimum if

$$\bar{n}^2 = \overline{N},\ \bar{n}.\overline{M} = 2\overline{N}; \qquad (10)$$

hence $\overline{M} = 2\overline{N}^{1/2}$, which gives the simple rule that for optimum analysis one must take one exploring electron for every step in the scale of photons, and the interchange n must be itself equal to one distinguishable step. The relative uncertainty in measuring the amplitude now becomes, neglecting the first small term at the right-hand side of equation (9), equal to $(2/\bar{n})^{1/2} = 2^{1/2}/\overline{N}^{1/4}$. This is $\sqrt{2}$ times larger than the square root of the relative uncertainty in the scale of the photons. This proves that the ladder of the amplitudes will contain always less steps than $\sqrt{S}$, according to equation (5); apart from the factor $\sqrt{2}$, for the reason that the optimum setting is possible only for one level, for example, for the maximum level to be expected, for weaker signals the uncertainty will be necessarily more than the minimum. A similar argument applies to the measurement of the phase. Summing up, we see that the classical description of the signal, in terms of amplitude and phase, by being too detailed, gives, in fact, a smaller number of ascertainable data on the signal than the quantum description—in the useful terminology of D. M. MacKay[5], it has a smaller 'metron-content'.

The difference, though theoretically interesting, may be of small importance practically, particularly if we take into consideration that we have really compared a classical exploring device with an ideal photon counter. But such counters are not available in the range of frequencies used for electrical communications; hence in this region classical detectors may well be the best. Things are different in the optical region, where detectors of the 'counter' type —such as the eye—are approaching perfection. In this region analysis in terms of waves is as yet

technically impossible, but it is interesting to note that, even if it were possible, it would not be very practical. It takes about one hundred million photons per information cell in order to define amplitude and phase to 1 per cent each. In the visible region, this means already signals of very appreciable intensity.

These considerations suggest that the idea of information, which originated in the theory of communications, may well prove a fruitful concept when applied to physics.

[1] cf. Born, M., "The Natural Philosophy of Cause and Chance", 81 (Oxford, 1949).
[2] Gabor, D., *Nature*, **159**, 303 (1947); *J. Inst. Elect. Eng.*, **93**, 429 (1946).
[3] Smith, Lloyd P., *Phys. Rev.*, **69**, 195 (1946).
[4] *Phil. Mag.* (in the press).
[5] MacKay, D. M., *Phil. Mag.* (7), **41**, 289 (1950).

MASSES OF FUNDAMENTAL PARTICLES

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In a recent note, Flint[1] suggested that the "fundamental length" $h/m_p c$ should be identified with the classical radius of the electron $ke^2/m_e c^2$ (where m_p, m_e are rest masses of proton and electron, and k is a universal, dimensionless constant), both having the meaning of ranges of nuclear forces. This leads at once to the expression

$$\mu \equiv \frac{m_p}{m_e} = \frac{ch}{ke^2} = \frac{2\pi}{\alpha k} \equiv a \qquad (1)$$

(where α is the fine-structure constant) for the mass ratio of proton and electron. He showed that this relation is satisfied with a remarkable accuracy if the value $k = 15/32$ is used which I derived from theoretical considerations in a paper[2] in which expression (1) was first deduced from a new basic principle. In the present communication I wish to show that this principle can be generalized in such a way that it not only yields the mass ratio μ, but also the electronic mass numbers of all the other hitherto observed fundamental particles in terms of pure numbers, without the introduction of any arbitrary constants. This is not the case with various other suggestions[3] of a purely empirical character for deriving these mass ratios.

The new principle can be expressed in the following propositions:

(I) The fundamental length or 'radius' to be associated with a neutral particle of rest mass m_0 is its 'Compton wave-length', $h/m_0 c$.

(II) For a particle of zero rest-mass (photon) the corresponding length is equal to the wave-length $\lambda = c/\nu$.

(Propositions (I) and (II) follow directly from my "hypothesis of elementary indeterminacy"[2].)

(III) The 'radius' of a charged particle of rest-mass m_0 is equal to $ke^2/m_0 c^2$ with $k = 15/32$.

(IV) The radius of a neutral nucleon is identical with the range of its nuclear field[4,5].

(V) In a process of transmutation of fundamental particles, the 'radii' of the primary and secondary particles satisfy the equation

$$\Sigma_i \delta_i r_i = 0 \quad \text{with} \quad |\delta_i| = 1,$$

in which the expressions (III) are to be used for particles interacting electromagnetically, and expressions (I) and (II) in all other cases.

(According to the hypothesis of elementary indeterminacy, the product of the 'radius' and the 'fundamental momentum' associated with a particle is equal[2] to h. Hence proposition (V) is 'reciprocal' in the sense of Born's theory[6] to the law of conservation of momentum.)

Consider first the process of β-decay, that is, the transmutation of a neutron into an electron and a proton. Here we have

$$\frac{h}{m_n c} + \frac{ke^2}{c^2}\left(\frac{\delta_1}{m_e} + \frac{\delta_2}{m_p}\right) = 0 \qquad (2)$$

(where m_n is mass of neutron), which is to be combined with the energy equation

$$m_n c^2 = m_e c^2 + m_p c^2. \qquad (3)$$

Taking into account that $a \gg 1$, one can easily show that the only admissible solutions of (2) and (3) are

$$\mu = a \quad \text{and} \quad \mu = 1/a.$$

They are, of course, equivalent and mean that the two secondaries must have a mass ratio which, with Eddington's value $\alpha = 1/137$ of the fine-structure constant, can be expressed as a pure number, namely,

$$\mu = \frac{2\pi \times 32 \times 137}{15} = 1836{\cdot}4 \qquad (4)$$

(observed value, 1836·57).

Relations (2) and (3) also hold for the process of the decay of a proton into a positron and a neutron, and therefore the principle demands that the masses of electron and positron be practically identical.

The result (4) is also compatible with the transmutation of a neutron into a positron and a 'negative proton' or 'antiproton', which would have to have the same mass as the proton. This consequence of the theory was pointed out by me in a paper published in 1933[7], and later the possibility of the existence of a negative proton was repeatedly discussed by a number of physicists[8], apparently without knowledge of that publication. It was further pointed out in that paper that in a closed part of the universe only one sort of positive and one sort of negative stable fundamental particle could exist simultaneously, because pairs of electrons and positrons, and also pairs of protons and antiprotons, would continue to annihilate each other until only one type of light particle and one type of heavy particle with opposite charges would survive. However, the possibility of an occasional creation of antiprotons (with very short life-time) is indicated by the argument in (3).

Proposition (IV), combined with Yukawa's expression $h/2\pi m_\pi c$ for the range of nuclear forces due to the presence of 'nuclear mesons' of mass m_π, leads to[4]

$$\frac{m_n}{m_\pi} \approx \frac{m_p}{m_\pi} = 2\pi. \qquad (5)$$

If (5) is combined with (4), the electronic mass number of the 'π-meson' can be expressed in terms of pure numbers

$$\frac{m_\pi}{m_e} = \frac{32 \times 137}{15} = 292 \text{ (observed value, } 285 \pm 5). \qquad (6)$$

Next consider the interaction of a π-meson with a neutron, resulting in the formation of a secondary (μ-) meson. This can be regarded as a transmutation of two primary particles with masses m_n, m_π into two secondary particles with masses m_n, m_μ. From (V) we have

$$\frac{h}{m_\pi c} + \frac{\delta_1 h}{m_\pi c} + \frac{\delta_2 h}{m_\pi c} + \frac{\delta_3 h}{m_\mu c} = 0. \quad (7)$$

It can easily be verified that the only solution of this equation compatible with the condition $\varepsilon \equiv \frac{m_\pi}{m_\mu} > 1$, is

$$\varepsilon = 1 + 2\frac{m_\mu}{m_\pi}. \quad (8)$$

If this is combined with (5), one obtains

$$\varepsilon = 1 + \frac{1}{\pi} = 1{\cdot}32 \text{ (observed value, } 1{\cdot}33 \pm 0{\cdot}05), \quad (9)$$

a relation which was first derived by me from a less general consideration[4].

From (6) and (9) follows the value for the electronic mass number of the μ-meson:

$$\frac{m_\mu}{m_e} = \frac{292}{1{\cdot}32} = 221 \text{ (observed value, } 216 \pm 5). \quad (10)$$

Consider finally the process of annihilation of a proton and an antiproton. The annihilation of an electron and a positron results in the formation of two equal photons. I suggest that the annihilation of a proton and an antiproton, as this involves electromagnetic and nuclear interaction fields, results in the creation of a pair of photons and a pair of neutral mesons ('neutrettos') or charged mesons.

In the first case, we may replace the process by two identical processes of transmutation of a neutron into a photon and a neutretto of mass m_τ. For this, proposition (V) provides the equation

$$\frac{h}{m_n c} + \frac{\delta_1 c}{\nu} + \frac{\delta_2 h}{m_\tau c} = 0, \quad (11)$$

to which has to be added the energy relation

$$m_n c^2 = h\nu + m_\tau c^2. \quad (12)$$

It can again easily be shown that the only possible values for the energy ratio $\eta \equiv \frac{m_\tau c^2}{h\nu}$ of neutretto and photon, resulting from this equation, are

$$\eta_1 = \frac{1+\sqrt{5}}{2} = 1{\cdot}618 \text{ and } \eta' = \frac{\sqrt{5}-1}{2} = \eta_1 - 1 = \frac{1}{\eta_1}. \quad (13)$$

Thus the two types of created particles have the fixed energy ratio η_1.

From (12) and (13) one obtains two possible values for the mass ratio m_n/m_τ, namely,

$$1 + \eta_1 = 2{\cdot}618 \text{ and } 1 + \eta' = \eta_1 = 1{\cdot}618,$$

from which by means of (4) the electronic mass numbers of the two possible neutrettos are calculated:

$$m_\tau/m_e = 701 \quad \text{or} \quad m_\tau/m_e = 1{,}135. \quad (14)$$

I venture to suggest that such a neutretto can in turn produce a pair of τ-mesons by interaction with a nucleon, in analogy to the process of 'pair-production' by a photon, and that this is the process first described by Rochester and Butler[9] and more recently by Anderson and collaborators[10] in what they call "decay of the first kind".

If, on the other hand, the annihilation process of proton and antiproton results in the creation of a pair of charged mesons, it cannot be split up into two symmetrical halves as considered above, and hence the present theory is not capable of predicting the masses of these mesons. It seems not unreasonable, however, to assume that these mesons may have a continuous mass spectrum within the limits of (14). They could therefore be identical with the so-called τ-mesons which have been described by various observers[11]; indeed, the most recent determination of the masses of these particles by Butler, Rosser and Barker[12] gives the limits 650–1,140 m_e.

The process of the transmutation of a τ-meson into a lighter particle, first observed by Rochester and Butler[9] and more recently by Anderson and collaborators[10], in their "decay of the second kind" process, may well be analogous to the transmutation of a π-meson into a μ-meson. The mass m_τ' of the secondary particle would then, according to (8), be given by

$$\frac{m_\tau}{m_\tau'} = 1 + 2\frac{m_\tau}{m_n} \sim 2. \quad (15)$$

As I have already emphasized elsewhere[5], it is indeed in keeping with the principles of the present theory to ascribe a continuous mass spectrum to mesons in analogy to the continuous frequency spectrum of photons. The appearance of mesons with specific rest masses must be regarded as the outcome of specific nuclear processes, just as the appearance of specific spectral lines is the outcome of specific electronic processes in the atomic shells.

[Aug. 7.

[1] Flint, H. T., *Nature*, **166**, 30 (1950).
[2] Fürth, R., *Z. Phys.*, **57**, 429 (1929).
[3] For example, Freeman, I. M., *Nature*, **165**, 933 (1950). Stephenson, G., *Nature*, **165**, 1018 (1950).
[4] Fürth, R., *Nature*, **162**, 772 (1948).
[5] Fürth, R., Research (Colston Papers on Cosmic Radiation), 149 (1949).
[6] Born, M., *Proc. Roy. Soc.*, A, **165**, 291 (1938): for list of references to other papers, see *Nature*, **165**, 269 (1950).
[7] Fürth, R., *Z. Phys.*, **85**, 294 (1933).
[8] For list of references, see Broda, E., Feather, N., and Wilkinson, D. H., International Conference on Fundamental Particles, 114 (1947).
[9] Rochester, G. D., and Butler, C. C., *Nature*, **160**, 855 (1947).
[10] Anderson, C., *et al.*, *Phys. Rev.*, **78**, 290 (1950).
[11] For references, see, for example, *Nature*, **166**, 16 (1950).
[12] Butler, C. C., Rosser, W. G. V., and Barker, K. H., *Proc. Phys. Soc.*, A, **63**, 145 (1950).

MARINE BIOLOGY RESEARCH IN GREAT BRITAIN

NINETEEN papers on the physical and chemical properties of sea-water, movement of water on the ocean bed, and the life-history and habits of the animals living in the sea, make up a well-balanced group in the December issue of the *Journal*, issued by the Marine Biological Association of the United Kingdom.

A second paper by Mr. G. A. Steven on the biology of the mackerel (*Scomber scombrus*) is based largely on observations and plankton samples collected by fishermen engaged in the Newlyn deep-sea mackerel fishery, sole relic of the three West-Country fisheries, for the inshore Newlyn and Plymouth fisheries are no longer remunerative. P. G. Corbin (1947) mapped the spawning areas in the Celtic Sea, north-west and south-west of the Cornish peninsula, and Steven found that the most productive fishing areas lie on the fringes of those areas nearest to the land, from about one hundred miles west of the Scillies in March, and moving shorewards as the fish rise from the sea bed and migrate to shallower waters for active feeding. The post-spawning anadromous migration is correlated with the 'yellow water' recognized by

the fishermen, and this proved on investigation to be water rich in zooplankton, particularly copepods.

Mr. Corbin contributes his tenth paper on the seasonal abundance of young fish, for the year 1948. A continuation of the decline in the population of young fish, coupled with that of the planktonic organisms on which they feed, is in great contrast to the rich hauls of the year 1930, and the fortnightly averages of some species are now so low that they cannot be graphed against similar averages for the period 1930–34. Clupeids provide the highest figures, particularly in March and October. None was recorded in November, the only month in which they were absent. The haul of pilchard eggs in June was barely one-third that of a good year. Plankton other than young fish were also scarce. *Calanus*, *Sagitta setosa* and *Muggiæa atlantica* show very low records.

The link between the larval stage and the adult form, so ably worked out in many species by Dr. Marie Lebour, is the subject of three papers in the present issue. One, by Dr. Lebour herself, deals with the last larva and post-larva of *Typton spongicola*. This peculiar deep-orange larva was taken off the Eddystone, and changed in the laboratory to the post-larva, with loss of its double flexion but retention of the humped abdomen. The antennal scale and the exopodite of thoracic appendages 4–7 show a progressive decline from larva to adult. Nothing is known of the transition from the free post-larva to the sedentary adult living within a sponge. A similar post-larva was found in Bermuda in 1940 by Dr. Hilary Moore.

Mr. R. H. Millar describes the larval stage of *Didemnum maculosum*, a compound ascidian forming mouldy-looking incrustations on *Laminaria* roots in the littoral zone. The larva possesses four rows of stigmata and other pharyngeal characteristics of the adult zooid of the family Didemnidæ, but has only two anterior adhesive organs as in *Trididemnum alleni*.

Our knowledge of the life-history and local distribution of *Arenicola marina* has expanded considerably during the past few years, owing to the careful and intensive studies of G. P. Wells, G. E. Newell and G. Chapman. In the present number the last two authors have worked out that the population density of lugworms in inter-tidal zones with high organic content depends upon particle size and depth of the 'top-soil'. Worms do, however, migrate from less to more favourable areas, especially in spring. In this way they came to inhabit a large mine crater on the Whitstable flats which had afterwards filled up with soft sandy mud in a bowl of clay. Dr. Newell was the first to discover the spawning and the early larval stages of *Arenicola marina* in Great Britain, and he now follows up the life-history by a study of the development between the larva with three chætigerous segments and a post-larva, about 3 mm. long, with twenty chætigerous segments and six eyes, but no branchiæ. These post-larval stages are bottom dwellers enclosed in mucous tubes on pebble and *Fucus* zones, the habitat bearing out Newell's earlier suggestion that the lugworm has no pelagic stage in its life-history.

As a foretaste of the eagerly awaited Ray Society monograph on the Mysidacea by the late Prof. W. M. Tattersall, which Mrs. Tattersall has prepared for the press, she gives a key for the mysids of the Plymouth area, which will prove useful to those of us who supplement daytime plankton hauls with coarse-net hauls at night.

The invasion of British shores by Mediterranean species occasionally occurs, and Miss U. M. Grigg describes the recent appearance of two large southern species of sea hares, *Aplysia depilans* and *A. limacina*, the former from Babbacombe and the latter from the Salcombe estuary. This is the third record from various points on the south coast of *A. depilans*, but the first of *A. limacina*. Dr. D. P. Wilson contributes beautiful photographs of the living animals.

Mr. G. M. Spooner investigated the absorption of strontium and yttrium by algæ, and found that radioactive strontium was taken up by brown seaweeds, *Fucus serratus* containing forty times as much as in sea-water, and about three times as much as *Laminaria digitata*. Red and green algæ absorb a negligible amount, *Rhodymenia* and *Ulva* containing less than in the sea. Radioactive yttrium is in inverse proportions, being least in the brown weeds. It is suggested that there is both ionic exchange and adsorption on surfaces, but in brown algæ primarily ionic exchange. *Nitzschia* takes up yttrium very heavily, probably by adsorption on the surface.

A preliminary article on volume measurement of water filtered by a plankton pump is contributed by Mr. H. Barnes, who uses an ex-National Fire Service pump, tests it by filling a tank and estimates the pumping-rate; filtering off the plankton would probably increase the accuracy. He suggests that the variability of net hauls is not entirely due to variation in the volume of water filtered, but this requires further investigation.

Dr. A. A. Aleem describes an ingenious apparatus for producing artificial tides in an inverted bell-jar by a drip-siphon method, which can be adjusted to give two high and two low tides within twenty-four hours. In a second paper he details a method for estimating quantitatively the periodicity of epiphytic marine diatoms by computing the amount of diatom silica, after washing free from sand. The method can be adapted for planktonic diatoms, provided that the sample does not contain other organisms having a siliceous envelope.

Dr. W. A. P. Black and Dr. E. T. Dewar have worked on the correlation between some of the physical and chemical properties of the sea and the chemical constitution of the algæ. The samples of sea-water from three localities on the Argyllshire coast do not differ materially from those elsewhere as regards estimations of *p*H, dissolved oxygen, nitrate and phosphate, in the different months of the year, August having the lowest record, though it has the highest temperature. Using species of *Laminaria* for the estimation of their chemical constituents, they found that a correlation does exist and that rapid photosynthesis occurs from March to early July, when nitrate and phosphate are plentiful, and are at their lowest in late July and August, but rise again in the autumn after vertical mixing and regeneration of the nutrients.

There are two papers on measurements of extinction coefficients. A quick method, taking only five minutes, for the determination of visibility depth in water, using selenium rectifier cells and colour filters, is described by Dr. W. R. G. Atkins, Dr. H. H. Poole and Mr. F. J. Warren, while Mr. M. H. W. Gall gives an account of his cruise in the North Sea and English Channel, during which extinction coefficients were determined at twenty-five stations, compared with

Secchi disk readings, and correlated with salinity and temperature.

Finally, an interesting paper on water movements, entitled "Cascading over the Continental Slope", by Dr. L. H. N. Cooper and Mr. D. Vaux, deals with the cooling and sinking of the surface water in some winters over the Celtic Sea to a depth of about a hundred fathoms. This heavy water, coming into contact with the sea bed of the continental shelf, moves down it and flows along the bottom to the greater depths beyond. Mr. G. A. Steven has suggested the term cascading for this movement, which the authors believe occurs in limited areas only. Cascading will convey not only oxygen and nutrients to the depths, but also phyto- and zoo-plankton, which may in turn affect the fish population. Local cascading over flat-topped banks on the continental shelf during autumn cooling may favour the concentration of fish over declivities. Compensation is brought about by inflow from the Atlantic surface-water, the North Sea and the Straits of Dover contributing little or none.

A supplementary list of insects and arachnids from the Plymouth shore areas has been added by Mr. R. E. Hall and Mr. H. C. Fountain.

N. B. Eales

FIFTH INTERNATIONAL CONGRESS FOR MICROBIOLOGY

THE fifth International Congress for Microbiology was held at Rio de Janeiro during August 17–24. On the evening before the Congress proper, an exhibition of microbiology, parasitology and hygiene was opened at the Ministry of Education and Public Health by the Minister, Dr. Pedro Calmon. In the same room there was the Palais de la Découverte exhibition on the "Life and Works of Pasteur": the French Ambassador was present and an address was given by Prof. René Farbe.

The first business on the morning of August 17 was the registration of members, and there followed a collective reception by the Minister.

In the afternoon the members were received at Catete Palace by His Excellency the President of the Republic, General Enrico Gasper Dutra, and then the Congress was formally opened at the Municipal Theatre, the President and many of his ministers being among those on the platform. Among others, the President of the Congress, Dr. Olympio da Fonseca, made a speech. After the opening session, members were taken to the Hotel Quintandinha and Petropolis, about forty miles away. The former served as headquarters for the Congress. It was most convenient for the majority to be housed and have their meetings in the same building. As it is 2,600 feet above sea-level the temperature was much more conducive to work than at Rio.

The programme was divided into eleven sections: 1, Microbiology; 2 (*a*) Medical, and (*b*) Veterinary Bacteriology; 3, Virus and Virus Diseases; 4, Rickettsiæ and Rickettsial Diseases; 5, Mycology; 6, Protozoology; 7, Plant Pathogenic Micro-organisms; 8 (*a*) Water, Sewage, and (*b*) Soil Microbiology; 9, Industrial Microbiology; 10, Immunology and Allergy; and 11, Classification and Nomenclature of Micro-organisms. The sessions were held from 9 a.m. until 1 p.m. on Friday, Saturday, Monday and Wednesday, the afternoons being devoted to meetings of committees and sub-committees on various subjects. At 5 p.m. and 9 p.m. there were special lectures, followed by entertainment of divers kinds.

The Congress was a great success in every way. A volume of abstracts of papers was available on the first day and daily bulletins were issued giving changes in the programmes of different sections. Arrangements for illustrating the papers were excellent.

Many problems of immediate scientific interest were discussed in the different sections, as would be assumed from the grouping of the papers. Some of the programmes were very full, particularly those of microbiology and mycology. The first dealt mainly with matters common to all sections. The success of the second was remarkable in every way. All aspects of medical mycology received notice and most groups of fungi were touched upon, Coccidioides and Paracoccidioides having most attention. The seriousness of deep-seated granulomas in South America and the frequency of other fungal diseases of man and animals have given mycology a prominent place in medical studies there. Many of the papers presented showed a pleasing acquaintance with the requisites of classification and correct identification. Medical mycology, a subject full of difficulties, has had these magnified by descriptions and drawings of fungi which could have had no existence—a fact which has deterred investigations, possibly more particularly in Great Britain, where though fungus diseases are of little practical importance they are certainly not so rare as is commonly assumed. There is no doubt that their importance in South America is realized and that excellent work is being carried out there. The deliberations of the section should have wide-reaching effects on medical mycology. Other aspects of mycology were considered in other sections, including that of plant pathology. It has been suggested that this last section should in future specialize in bacterial, protozoological and virus diseases.

On Sunday, after solemn mass at Petropolis Cathedral, some members went to the Jockey Club at Rio, while others visited the National Park at Teresopolis. This is one of the five Brazilian National Parks and is conveniently situated near Rio in the Organ Range. One of the objects of the Park is to demonstrate how the retention of the tree cover of mountain slopes prevents soil erosion: there is alarm everywhere about destructive exploitation, but apparently no unified action. The entrance to the Park has been made into a garden, but there is a tendency to make too many roads; also, in view of the great natural beauty, marigolds, pinks and other common European garden plants seem out of place.

Tuesday morning was spent visiting the famous Oswaldo Cruz Institute, which is celebrating its fiftieth anniversary, and of which Dr. Olympio da Fonseca, the president of the Congress, is the director. The scope of the investigations there being carried out is refreshingly wide and the morning proved all too short for the visit. After lunch at the Institute, Prof. Clementino Fraga gave a lecture at the Brazilian Academy of Letters on "Oswaldo Cruz: an Interpretation of Personality". There followed a reception by the Mayor of Rio at Guanabara Palace, and a performance which included an open-air ballet.

The main part of the final day was the closing session, at which the various recommendations of

committees and sub-committees were submitted for approval—one that there should be a halt in the attempts to provide complete schemes for virus nomenclature until the results of research now in progress give some sound basis for classification.

An invitation to hold the next Congress at Rome in 1953 was accepted. There was a banquet in the evening, with many speeches, and the final festive occasion was a dance.

Visits were arranged to places of interest, and many members flew to São Paulo after the Congress to visit the agricultural and medical institutes on Friday, and a snake farm on Saturday, followed by a barbecue.

J. RAMSBOTTOM

THE INSTITUTE OF PHYSICS

ANNUAL MEETING AND REPORT FOR 1949

AT the thirtieth annual general meeting of the Institute of Physics, held on July 20 at the Institute's House, 47 Belgrave Square, London, S.W.1, the following were elected to take office on October 1: *President*, Prof. W. E. Curtis; *Vice-President*, Prof. E. G. Cox; *Honorary Treasurer*, Mr. E. R. Davies; *Honorary Secretary*, Dr. P. B. Dudding; *New Ordinary Members of the Board*, Dr. F. P. Bowden and Mr. G. R. Noakes. Prof. H. W. Thompson joins the Board as the new representative of the Faraday Society.

The thirtieth annual report of the Board, covering the work of the Institute during 1949*, was adopted at the meeting. It records that the Board met six times, and its various standing committees twenty-five times, during the year. Applications for membership in the various grades received during 1949 numbered 652, including 126 to the new grade of graduateship of the Institute. The total membership increased by approximately 200 to 3,657. The Institute has now eight branches and seven specialist subject groups, the North East Coast Branch and the Education Group having been inaugurated in October. Details of the various activities of the branches and groups are given in the report. Many meetings were held and several laboratories were visited. The five divisions of the Australian Branch held thirty-nine meetings and a three-day conference on X-rays in industry in Melbourne during November. The Scottish Branch was responsible for a pioneer experiment in the arrangement of a course, which has attracted very large audiences, of eighteen weekly lectures on atomic and nuclear physics. The Institute collaborated with the H. H. Wills Physical Laboratory of the University of Bristol in a summer school during September on theoretical physics, and the Stress Analysis Group was responsible for two summer schools, one at University College, London, and the other in conjunction with the Engineering Laboratory of the University of Cambridge.

A new and outstanding event was the convention organised by the Institute and held in Buxton during May 19–21. Primarily a domestic affair, attendance was limited to members, members' ladies and a few distinguished guests. It proved most successful. More than four hundred people attended, and, in addition to social events such as the convention dinner and dance, visits to local beauty spots, places of interest, laboratories and works, symposia were held on physical analysis and testing, the development and application of X-ray analysis, and means of accelerating particles to high energies. The president, Dr. F. C. Toy, opened a discussion on "The Institute, Past, Present and Future", and Prof. A. M. Tyndall, a past president, spoke on "Atomic Particles—a Survey of Recent Discoveries". An exhibition, consisting of photographs, models and instruments, was an additional interesting feature of the convention.

The report mentions that applications from technical colleges for official recognition by the Institute as institutions suitable for the training of physicists continue to be received, and that to date twenty-eight colleges, after personal inspection by representatives of the Institute and of the Ministry of Education, have been granted official recognition. Nine colleges in England and Wales have had courses approved for Ordinary National Certificates in applied physics, and arrangements have been made with the Scottish Education Department for the establishment of similar courses in Scotland.

In accordance with the recommendation of its publications policy committee that the amount of the publications of the Institute should be considerably increased, arrangements were completed for the launching in January this year of the *British Journal of Applied Physics* (see *Nature*, April 29, p. 679), for the publication of further volumes in the "Physics in Industry" series, and for a monthly *Bulletin*, which also commenced in January. During 1949 a second edition of the "Handbook of Industrial Radiology" was published and also a selection, in book form, from the "Laboratory and Workshop Notes" which had appeared in the *Journal of Scientific Instruments*. The royalties from the sale of both these books are credited to the Benevolent Fund of the Institute.

It is an interesting but somewhat disturbing fact to find reported that of the 151 papers and 51 laboratory and workshop notes submitted for publication in the Institute's *Journal*, only 103 and 36 respectively were accepted and that, of these, 42 and 10 respectively required modification to meet the referees' requirements. It would appear that authors need to take more care to make sure that their work is of sufficiently high merit to warrant publication and that their articles are presented in a clear and concise form and in conformity with the particular requirements of the *Journal*.

The Institute continues to be represented on various joint committees and bodies. Details of these are listed in the annual report, and reports of some of the representatives of the Institute are given in an appendix. It is reported by the representative on the British Committee for Radiological Units that the Committee, in 1948, prepared a memorandum entitled "The Measurement of Ionising Radiations for Medical and Biological Purposes" in which it was proposed that a new unit, with the symbol *J*, be set up applicable to all ionizing radiations. This memorandum has been circulated to industrial and medical radiologists for comment.

The main part of the programme for the adaptation and renovation of the Institute's House in Belgrave Square was completed during the year, and the meeting and committee rooms have been in regular use. Owing to the continued growth of the work at the headquarters of the Institute, the post of deputy secretary has been created by the Board, and Mr. N. Clarke, who has been the assistant secretary since 1945, was appointed to the post as from January 1, this year.

* Thirtieth Annual Report of the Board of the Institute of Physics. Pp. ii + 12. (London: Institute of Physics, 1949.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Rachitogenicity of Green Oats

In 1944 it was reported[1] that young, green oats, grown in the South Island of New Zealand, appeared to be actively rachitogenic for sheep during their first winter. Further investigation[2], extending over several years and involving feeding trials with most of the commonly grown sheep fodder crops, as well as young mixed pasture and Italian ryegrass, confirmed the earlier results indicating that young green cereals (oats and barley) are strongly rachitogenic. The affected animals showed hypophosphatæmia positively correlated with the degree of rickets which developed, normal serum calcium values, varying degrees of lameness and severe retardation of growth. Chemical analysis of the green cereals invariably showed an adequate phosphorus content and a satisfactorily balanced calcium–phosphorus ratio. Vitamin D, given as cod liver oil twice weekly (45 ml. per sheep), or as a single massive dose of calciferol (25 mgm. in arachis oil), either orally or subcutaneously, was fully effective in preventing rickets and enabling a high winter growth-rate to be maintained. Calciferol in this dosage also brought about a speedy return to normal in affected sheep.

Oats were sown at this Department's farm in October 1948 and cut in April 1949, when approximately 9 in. high. A cloudy day with intermittent rain was chosen, and immediately after cutting the oats were carted to a nearby grass dryer and dried. The product, dark green and with an attractive smell, was fed to newly weaned lambs and guinea pigs.

Analysis. The dried oats were found to contain 11·98 gm. per cent crude protein, 1·92 gm. per cent calcium, 0·48 gm. per cent phosphorus and 0·8–1·2 I.U. per gm. vitamin D.

Feeding. (*a*) *Sheep.* Four newly weaned lambs of similar breeding and weight were fed to appetite on the dried green oats as their sole diet. Two of them were given a massive dose of vitamin D_2 (500,000 I.U. in arachis oil, subcutaneously) and two were untreated. The gains in weight of the four sheep varied between 0·29 lb./day and 0·39 lb./day, which may be considered satisfactory for sheep of this age[2]. The serum calcium values fell slightly during the experiment, but remained within the normal range. Blood inorganic phosphorus-levels also fell in all sheep, but to a greater extent.

Mean Serum Calcium and Blood Inorganic Phosphorus (mgm. per cent)

	16/5/49		11/7/49	
	Vitamin D-treated	Untreated	Vitamin D-treated	Untreated
Serum calcium	13·8	13·8	12·6	12·8
Blood inorganic phosphorus	5·4	5·2	4·7	3·9

Rickets developed in both lambs untreated with vitamin D, as revealed by radiographs and examination of sections of the costochondral junction obtained by means of rib resection at the beginning and end of the experiment. The pathological changes in the bones will be more fully described in a study of the relation of low phosphorus rickets and vitamin D in sheep, to be published elsewhere. The lambs treated with vitamin D showed these changes to a small degree; but they had only progressed to a stage which might be described as mild rickets when feeding had to be stopped because of shortage of dried oats.

During the later part of the experiment, the average consumption was approximately 800 gm. per sheep per day. This meant that each lamb was getting approximately 708 I.U. vitamin D daily, which is about five times their estimated requirement[3]; yet only when this was supplemented with large additional amounts of vitamin D_2 could rickets be avoided.

(*b*) *Guinea pigs.* It appeared that rats were not suitable for investigating the rachitogenicity of winter green oats[4], so guinea pigs were tried.

Three groups of six newly weaned guinea pigs were used, the first two groups receiving a diet which contained 80 per cent freshly cut green oats and 12 per cent dried green oats and the third group being maintained on our stock diet. Vitamin D_2 was given to group 2 at the rate of 8,000 I.U. per guinea pig at the beginning of the experiment and again 47 days after. The feeding period lasted 70 days.

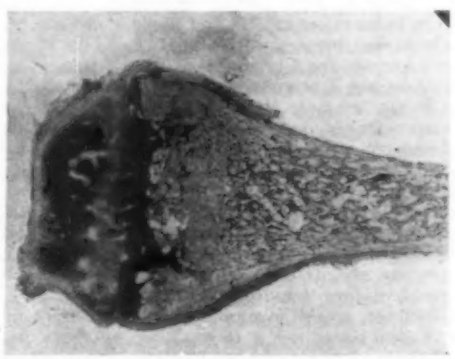
The growth-rates of the two oats-fed groups were closely comparable and not significantly less than that of the control group. The drop in blood inorganic phosphorus in the untreated oats group was, however, marked.

Mean Blood Inorganic Phosphorus (mgm. per cent)

Group	Treatment	3/5/49	15/6/49	1/7/49
1	Green oats	4·2	1·7	2·2
2	Green oats + vitamin D_2	4·0	2·3	3·1
3	Stock diet	4·6	4·8	4·5

The fall in the blood phosphorus values in the guinea pigs of group 1 coincided with the appearance of rachitic changes in radiographs of the distal epiphysis of the radius. The severity of the rickets which developed in the guinea pigs unprotected by additional vitamin D_2 is illustrated in the accompanying photograph.

Although autumn-sown green oats grown near Cambridge were shown to be strongly rachitogenic for sheep and guinea pigs, they have not exhibited the growth-retarding effect associated with the New Zealand green oats. Field studies in that country[2] showed that, while poor growth was certainly most



Guinea pig No. 20: rickets. Costochondral junction showing cartilage proliferation and irregularity, increased osteoid and vascularity. × 18

marked in the rachitic sheep grazing green oats, it also occurred in non-rachitic sheep, grazing other winter fodder crops, which had not received additional vitamin D. Growth could be significantly increased by giving a massive dose of vitamin D_2. In other words, there appears to be two factors present in green oats (Algerian) grown in New Zealand, one growth-retarding and one rickets-producing; while in green oats (Winter White) grown in England, only the rickets-producing factor is present.

No structural analogue of any of the fat-soluble vitamins has so far been discovered which has anti-vitamin effect in the manner of those synthesized and antagonistic to members of the vitamin B complete[5], or, among biological material, in the way that dicoumarol, found in spoiled sweet clover, is an anti-vitamin K. It seems to me unlikely that we are dealing with an antivitamin of this nature in green oats, for the onset of rickets occurs too suddenly in sheep given this feed for it to be due even to the complex withdrawal of vitamin D activity. Further, there is the fact that calcium absorption is not interfered with and that additional calcium carbonate exacerbates the disease[2].

It appears, then, that we are dealing with a 'toxamin'[6] or 'conditioning factor'[7] in the young oat plant which specifically interferes with the uptake of phosphorus in much the same way as phytic acid, found in high concentration in some cereal grains but not in the young plant, interferes with phosphorus absorption in many monogastric animals, including man.

Feeding experiments, in which rats and mice have also been tested, are now proceeding with various fractions of the green oats, as the next step towards discovering the identity of the rachitogenic factor.

I am indebted to Dr. W. J. Cuthbertson, of Glaxo, Ltd., for the vitamin D assay of the artificially dried green oats.

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June 23.

[1] Fitch, L. W., and Ewer, T. K., *Aust. Vet. J.*, **20**, 220 (1944).
[2] Ewer, T. K., and Bartrum, P., *Aust. Vet. J.*, **24**, 73 (1948).
[3] Andrews, E. D., and Cunningham, I. J., *N.Z. J. Sci. Tech.*, **27A**, 223 (1945).
[4] Filmer, J. F., Rep. Dir.-Gen. N.Z. Dept. Agric., 1949.
[5] Woolley, D. W., *Physiol. Rev.*, **27**, 308 (1947).
[6] Mellanby, E., *J. Physiol.*, **61**, 24 (1926).
[7] Ershaff, B. H., *Physiol. Rev.*, **28**, 107 (1948).

Significance of the 'Silent Period' of Muscles

The most attractive theory of the silent period of muscle action potentials is that of Matthews[1,2] (following a speculation of Fulton and Pi-Suñer[3]). In his pioneer work on single nerve endings in muscle, he showed that during a twitch, at a time corresponding to the silent period, there was a pause in sensory discharge from the muscle spindles—the endings believed responsible for exciting postural muscular contractions through the stretch reflex. This cessation of excitatory impulses clearly explained the silent period in the motor discharge. Matthews pointed out that the arrangement of muscle spindles in parallel with the main contractile fibres (which is responsible for the pause during a twitch) formed a self-regulating device, or servo-mechanism, for controlling tonic contraction of the muscle. Increased load or the onset of muscular fatigue would cause

Record of the silent period in the human adductor pollicis muscle during a steady voluntary contraction. Top trace: mechanical tension. Bottom trace: action potentials. Time markers 10 msec. and 0·1 sec. Maximal motor stimulus to ulnar nerve delivered 0·1 sec. after start of sweep. Five sweeps superimposed to show the regularity

elongation of the spindles, thereby reflexly calling up a greater contraction of the muscle tending to restore the system to its original length. The classical type of stretch reflex experiment discloses the static characteristics of the servo; the silent period is its transient response

In recent work on human subjects these ideas have been confirmed and extended. Evidence has been obtained by several independent methods that the duration of the silent period is determined only by the duration of the mechanical twitch of the muscle. For example, using the adductor pollicis, if the muscle is cooled by immersion in cold water, both the twitch and the silent period last longer. Such experiments, which will be described in full elsewhere, demonstrate that the silent period is, indeed, a reflex expression of changes in the afferent inflow from the muscle during its twitch. The records also reveal that in the intact subject the transient response is regular and practically non-oscillatory. In view of the long time lag for nervous conduction round the servo loop (about 35 msec. in the case of the hand muscles), some kind of stabilization must be employed to prevent oscillation: it is conjectured that this is achieved (in a way familiar to the servo engineer) by the use of derivative feedback from the muscle spindles. Matthews showed that the spindles were, in fact, particularly sensitive to rate of change of length, the instance of this property most relevant here being that the pause in discharge during a muscle twitch is briefer than the twitch causing it. For effective stabilization the ratio of derivative to linear feedback required from the spindle depends on the time lag round the loop and the twitch duration. The second conjecture is that this ratio (which will be different in different muscles and under different conditions of temperature and fatigue) is adjustable by means of the motor nerve supply to the intrafusal muscle fibres of the spindle. Here again Matthews provides evidence that the response of the spindle is altered by contraction of the intrafusal fibres.

This theory cannot be regarded as in any way established by the available facts, but its implications are wide and suggestive of new experiment; it introduces a new degree of freedom into the stretch reflex; not only is the gain round the loop (reflex briskness)

to be considered, but in addition the type of feedback can vary under the influence of motor discharge to the intrafusal muscle bundle with decisive influence on the characteristics of the servo. For example, the symptoms of spasticity might be due not, as Hughlings Jackson thought, to overactivity of the spinal cord consequent on its release from higher control, but to mere lack of control over the response of the muscle spindles—a notion which emphasizes our almost complete ignorance of the central connexions of the motor nerve fibres going to the spindles, although in number they are a large proportion of the total[4].

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[1] Matthews, B. H. C., *J. Physiol.*, **72**, 153 (1931).
[2] Matthews, B. H. C., *J. Physiol.*, **78**, 1 (1933).
[3] Fulton, J. F., and Pi-Suñer, J., *Amer. J. Physiol.*, **83**, 554 (1928).
[4] Leksell, L., *Acta Physiol. Scand.*, **10**, Supp. 31 (1945).

Effect of Indole and some Indolic Compounds on Muscle Sensitivity to Acetylcholine and Potassium

AMONG the indolic compounds formed from tryptophane in animal intestine, indole, skatole and indolethylamine are those reported to have the strongest pharmacological action. Their effect on plain or striated muscle has been studied in the past, either *in vivo* or in the isolated organs, although with no clear and consistent results[1-5]. More recently, Torda and Wolff[6] have examined the effect of indole, skatole, indole-3-acetate and tryptophane on the sensitivity of frog striated muscle to acetylcholine and potassium, finding that only indole increases the response to acetylcholine, while indole, skatole and indoleacetate increase the potassium effect. Since the presence in the bowel of indole and allied compounds seems to be a normal fact[7], and that the intestinal membrane can absorb and fix significant amounts of indole[8], and presumably other indole compounds as well, it seemed interesting to study their effect on the intestinal smooth muscle, as it might have implications in regard to the alterations of intestine motility.

Stimulant	Inhibitor	Per cent diminution of shortening
1·1 μgm. AcCho.	$2·0 \times 10^{-4}$ *M* indole	17·2 ± 1·4*
3·0 mgm. KCl	$1·2 \times 10^{-4}$ *M* ,,	7·4 ± 1·1
1·2 μgm. AcCho.	$1·1 \times 10^{-4}$ *M* skatole	54·4 ± 2·6
3·0 mgm. KCl	$1·1 \times 10^{-4}$ *M* ,,	53·0 ± 3·9
3·0 mgm. KCl	$1·5 \times 10^{-4}$ *M* indole	10·4 ± 1·8
3·0 ,, ,,	$4·2 \times 10^{-4}$ skatole	15·0 ± 0·3
3·0 ,, ,,	Indole plus skatole	30·0 ± 1·4
5·0 μmgm. AcChol.	$1·8 \times 10^{-4}$ *M* indole	12·8 ± 2·9
5·0 ,, ,,	$2·7 \times 10^{-4}$ *M* skatole	13·8 ± 2·9
5·0 ,, ,,	Indole plus skatole	31·4 ± 2·0

*Probable error (see ref. 9).

Diminution (average of three to five experiments) produced by the inhibitor on the shortening of the muscle induced by acetylcholine (AcChol.) or potassium (KCl). Contractions in the presence of the inhibitor have been considered only when intercalated between two control contractions of the same height. Terminal portion of guinea pig ileum immersed in 18–22 ml. Tyrode solution, saturated with oxygen containing 5 per cent carbon dioxide at 38°. The amount of the muscle contraction was registered on a kymograph by an isotonic lever and measured

With a technique similar to that employed by Torda and Wolff[6], we have studied the effect of indole, skatole, potassium indoxylsulphate, indoleacetate, indolethylamine, indolepropionate and L-tryptophane on the sensitivity to potassium and acetylcholine of the terminal portion of the guinea pig ileum and, for comparison, the frog (*Leptodactylus ocellatus* (L.) Gir.) anterior rectus abdominis. When using the striated muscle we have been able to confirm Torda and Wolff's results; but with the smooth muscle the effect of the indolic compounds was completely different. As it is shown in the accompanying table, which reproduces typical experiments, relatively small concentrations of skatole and indole, which *per se* do not affect significantly the tonus or contractility of the intestine, diminished the shortening induced by potassium or acetylcholine. The inhibition was reversible, and required for its full development about 5–10 min. incubation of the intestine with the inhibitor. The pI_{50} ($-\log_{10}$ molarity producing 50 per cent inhibition) of indole and skatole were 3·3 and 4·0 respectively, with acetylcholine as stimulant. The relaxation of the intestine when contracted by acetylcholine alone was also affected by indole and skatole, proceeding in the presence of the inhibitors at a slower rate, and in some experiments the muscle remained in the contracted state. When acting together, indole and skatole added their effects either on contraction or relaxation. Indolethylamine slightly increased the effect of acetylcholine on smooth muscle, while indoxylsulphate increased the effect of potassium on the striated muscle. Indoleacetate, indolepropionate and L-tryptophane did not modify the effect of potassium or acetylcholine on the guinea pig ileum when tested in concentrations near or higher than those used for indole and skatole.

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[1] Yanai, B., *Tohoku J. Exp. Med.*, **25**, 385, 401, 407 (1935).
[2] Waddell, J. A., *J. Pharm.*, **31**, 205 (1927).
[3] Eta, H. N., and Feinberg, I. M., *Amer. J. Physiol.*, **136**, 646 (1942).
[4] Garcia Blanco, J., del Castillo, J., and Rodeles, J. F., *Rev. Soc. argent. Biol.*, **17**, 473 (1941).
[5] Guggenheim, M., and Löffler, W., *Biochem. Z.*, **72**, 303 (1916).
[6] Torda, C., and Wolff, H. G., *Amer. J. Physiol.*, **145**, 608 (1945).
[7] Alvarez, W. C., *Physiol. Rev.*, **4**, 352 (1924).
[8] Nicolai, H., *Klin. Wschr.*, **21**, 108 (1942).
[9] Crumpler, T. B., and Yoe, J. H., "Chemical Computations and Errors" (London: Chapman and Hall, Ltd., 1940).

Physiological Action of the Toxin of the Egyptian Scorpion

THE main physiological effects produced by the toxin of the Egyptian scorpion[1] are: (1) inhibition of rabbit smooth muscle; (2) acceleration of the isolated rabbit and frog heart (antagonized by ergotoxin); (3) rise of blood pressure of the dog (reversed by ergotoxin); (4) vomiting, and contraction of intestine and bladder of rabbit and dog in the intact animal (antagonized by atropine).

In considering whether the toxin acts as a stimulator of sympathetic nerve endings, a study has been made of the effect of the toxin on the blood-sugar levels of normal and immune animals. Using the method of Hagedorn and Jensen, it was found that

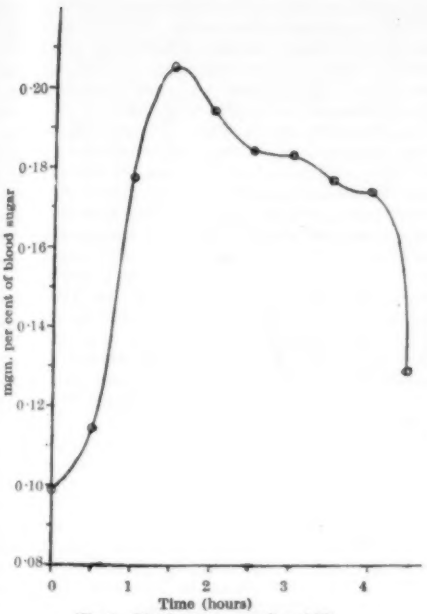

Fig. 1. Blood-sugar curve for rabbit

a blood-sugar level of 1·02 mgm./ml. increased to 1·39 mgm./ml. thirty minutes after the injection of 1 mgm. of toxin; and to 2·59 mgm./ml. one hour after injection. The injection of a sublethal dose of toxin into fasting rabbits was followed by a considerable rise, which reached a maximum an hour after injection, and was maintained for a time which varied usually with the dose of toxin injected. Fig. 1 is a typical blood-sugar curve of a 2-kgm. rabbit, fasted for 12 hours, and then injected with 1 mgm. toxin subcutaneously.

In some experiments with dogs, No. 1 (13·84 kgm.) had 0·0625 gm. per cent of sugar in the blood; after injection with 0·346 gm. of toxin, this had increased to 0·085 gm. per cent 90 min. later, and to 0·107 gm. per cent in two hours. The injection of sublethal doses of toxin into fasting non-immunized dogs was always followed by an increase which attained a maximum in about two hours; this high level was maintained for a time which varied usually with the dose of toxin injected. Fig. 2 is a typical blood-sugar curve of a dog (No. 2, 14·48 kgm.) injected subcutaneously with 0·241 gm. toxin (after being starved for 12 hours).

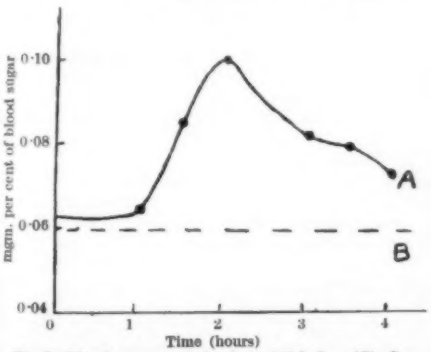

Fig. 2. Blood-sugar curve for dog: (*A*) before, (*B*) after immunization

When a lethal dose of toxin was injected into fasting, immunized dogs[2], no increase whatever in the blood-sugar level occurred, and this remained unaltered for at least five hours. Moreover, when a lethal dose of toxin, previously neutralized with antitoxin and the mixture incubated for 1 hour at 37°, was injected into fasting, non-immunized dogs of the same weight, the blood-sugar level remained unaffected.

The experiments demonstrated, therefore, that the subcutaneous injection of sublethal doses of scorpion toxin into rabbits and dogs causes hyperglycæmia; and that this effect ceases to be shown as immunity is developed.

My thanks are due to Prof. A. Hassan for his help in this work.

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[1] For earlier papers dealing with these toxins, see *Biochem. J.*, **38**, 284 (1944).

[2] *Lancet*, ii, 364 (1942).

Determination of Rate of Secretion of Thyroxine in the Male Rabbit

BROADLY speaking, the rate of secretion of thyroxine is the amount of thyroxine secreted into the general circulation by the thyroid gland in a given period of time under specified conditions. The secretory activity of the thyroid is generally regarded as being governed by an interaction and balance between the thyroid hormone and the anterior pituitary thyrotrophin.

In the present investigation, the rate of secretion of thyroxine of the growing male rabbit (thyroxine and thiouracil injected simultaneously for a period of two weeks), at 4, 8, 16, 32 and 48 weeks of age, was estimated by a technique in which varying levels of L-thyroxine were injected daily subcutaneously into the animals with the simultaneous administration of 0·1 per cent thiouracil as part of the ration for a period of four weeks. The administration of thiouracil prevented the synthesis of thyroxine by the thyroid gland; the resultant lowered thyroxine level in the blood stimulated the secretion of thyrotrophin, which in turn caused thyroid enlargement. By injecting graded dosages of L-thyroxine, the weight of the thyroid was reduced in the thiouracil-treated rabbits and the reduction in general was proportional to the thyroxine dosage. Thus the establishment of a normal thyroxine–thyrotrophin equilibrium by injection of thyroxine in the thiouracil-treated animal resulted in a thyroid weight equal to that of the control. The quantity of thyroxine required to bring about this result was considered to be an estimate of the normal rate of secretion of thyroxine by the thyroid.

It was observed that the rate of secretion of thyroid increased with advancing age in the male rabbit, and the estimated rates of secretion of L-thyroxine in a 4- and 48-week old male rabbit were 8·4 and 21·9 μgm./day respectively. However, when calculated per 100 gm. body-weight, the rate decreased with advancing age. The relation of the thyroid secretion-rate to body-weight can be expressed by the equation

$y = 0{\cdot}43x^{0{\cdot}48}$, where y is the amount in micrograms of L-thyroxine secreted per day and x is the body-weight in grams.

A decrease of about 23 per cent in the daily rate of secretion of thyroid of 16-week old male rabbits was observed during the summer months when compared with that estimated during the winter. This decrease in the rate of thyroid secretion may be due to differences in the environmental temperature. Castration of the male rabbit at the age of 8 weeks resulted in a decrease of about 30 per cent in the rate of secretion of thyroxine after a period of 24 weeks, when compared with the control; but no effect was observed on the weight of the thyroid after a period of 4 weeks. This shows that age is an important factor in augmenting the effect of castration on the rate of secretion of thyroxine of the male rabbit. The results of the present experiments will be described fully elsewhere.

I wish to thank Dr. J. Hammond and Dr. Arthur Walton for their interest and for providing facilities in their laboratories.

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Mechanism of Epinephrine-induced Tachycardia in the Frog

Although epinephrine was the first hormone isolated, knowledge of its mechanism of action has remained negligible. One method of attacking the problem of its mode of action is through a study of antagonists; this method has now provided somewhat unexpected information on the subject.

Adrenergic blocking agents, in general, fail to antagonize the chronotropic and inotropic responses of the mammalian heart to epinephrine, but results with the frog heart have been highly variable[1]. Studies on isolated, perfused hearts of *Rana pipiens* in our laboratory during January 1949 indicated that 'Dibenamine' and a number of its active congeners (β-haloalkylamines), and several ergot alkaloids are all capable of blocking the chronotropic response to epinephrine. The inotropic response is unaffected. Attempts to extend these results during February and March produced conflicting results and by the end of March the 'Dibenamine'-type blocking agents were completely ineffective and the ergot alkaloids were only about 10 per cent as effective as previously. Further studies on this seasonal variation demonstrated that resistance develops rapidly in late February and March and that sensitivity returns to a maximum during August.

The observed seasonal changes in sensitivity do not correlate well with seasonal temperature variations. However, temperature may be a factor in determining sensitivity. Cooling resistant animals to 4–8° C. for two to four weeks markedly increases the sensitivity of the heart to blockade; but cooling for only a few days is ineffective. The anterior pituitary gland proved to be the key to these changes. Small amounts of hog whole- or anterior-pituitary extract injected into the intact frog induce, within 12–24 hr., complete resistance to blockade by the β-haloalkylamines.

The chronotropic response of the heart is an expression of an increased energy metabolism. On the assumption that the resistance of the summer-frog heart might be due to the presence of some metabolic pathway by-passing the point of inhibition by the adrenergic blocking agents, an attempt was made to block its response by combining a β-haloalkylamine adrenergic blocking agent with various known metabolic inhibitors. Monofluoroacetate (3×10^{-7} *M*) and iodoacetate (1×10^{-6} *M*) combined with a β-haloalkylamine produced a blockade of the summer-frog heart comparable to that produced by the β-haloalkylamine alone in the winter-frog heart. Cyanide, azide, cadmium, arsenate, arsenite, fluoride, α,α-dipyridyl,3,4-dinitrophenol, malonate, pyrophosphate and iodoacetamide were completely ineffective. None of these inhibitors antagonized the chronotropic response to epinephrine when tested alone, and none altered the inotropic response, either alone or in combination.

The blocking activity of fluoroacetate and particularly that of iodoacetate, although iodoacetamide was completely inactive, suggested that acetate metabolism was involved in the chronotropic response of the frog heart to epinephrine. Glycerolmonoacetate effectively antagonizes the lethal action of fluoroacetate in mammals[2]. Consequently, the effect of this agent on the blockade of the chronotropic response produced by the adrenergic blocking agents, with and without added fluoroacetate, was studied. Glycerolmonoacetate (4×10^{-6} *M*) eliminates the blockade in a non-competitive manner, behaving always as a 'product' of the reactions blocked. Sodium acetate and glycerol are ineffective. Glycerolmonoacetate does not itself alter the inotropic response to epinephrine or the rate or strength of contraction in the absence of epinephrine. These results indicate that although the adrenergic blocking agents and fluoroacetate affect different metabolic pathways, they inhibit a similar step in metabolism.

Quantitative studies of the blockade were also carried out. The relationship between epinephrine and fluoroacetate or one of the adrenergic blocking agents is competitive, indicating common sites of action.

On the basis of the above results it may be concluded that the chronotropic response of the frog heart to epinephrine is dependent upon two distinct effects of the activating agent: (1) a stimulation of the production of 'utilizable acetate'; and (2) a 'trigger action' which is effective only in the presence of a suitable 'acetyl' substrate. The epinephrine-stimulated production of 'utilizable acetate' may proceed by two distinct pathways: a 'stable' path-

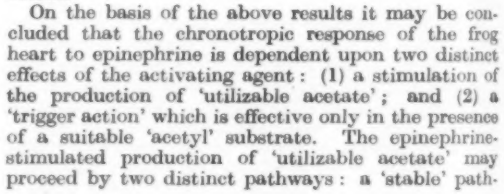

Diagram of possible points of action of epinephrine and certain blocking agents on the processes leading to the production of an epinephrine-induced tachycardia. *A* and *A'* represent metabolic substrates in the myocardium which may or may not be independent of each other. *B* and *B'* are parallel reactions affected by epinephrine and blocking agents. *C* depicts the final point of action of epinephrine in initiating the tachycardia

way which appears to be qualitatively and quantitatively constant throughout the year and which is blocked by β-haloalkylamine and ergot alkaloid adrenergic blocking agents, and a 'labile' pathway which normally functions only in the summer-frog heart, and which is activated by the anterior pituitary gland and is blocked by fluoroacetate and iodoacetate. Both these pathways appear to be completely independent of the energy sources utilized in the normal contraction of the heart and in its positive inotropic response to epinephrine. Epinephrine thus appears to promote the production of the metabolic substrate required for the expression of its own chronotropic action.

A full report of these studies will be submitted for publication in the *American Journal of Physiology*.

This investigation was aided by research grants from the National Institutes of Health, Public Health Service; the Smith, Kline and French Laboratories; and Sandoz Pharmaceuticals.

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[1] Nickerson, M., *J. Pharmacol. and Exper. Therap.* (*Pharmacol. Rev.*, 1), **95**, 27 (1949).
[2] Chenoweth, M. B., Scott, E. B., and Sekl, S. Louise, *Fed. Proc.*, **8**, 280 (1949).

Gonadotrophin from the Neural Region of Ascidians

POSTERIOR pituitary hormone analogues have been known from the neural region of Ascidians for some time[1,2], though doubt has been thrown on their reality[3]. One investigator only seems to have looked for anterior pituitary hormones[4]; he examined an extract from the neural region (ganglion + neural gland + ciliated pit) of *Polycarpa* for gonadotrophically active substance. Unfortunately, as he admitted himself, he had not sufficient material for an adequate test, so his results remained inconclusive and have not been generally accepted. In the course of other investigations I have had occasion to repeat this work using two other Ascidians, *Ciona intestinalis* (L.) and *Phallusia mammilata* (Cuv.).

The neural glands were ground with sand in acetone and hydrochloric acid to *p*H c. 1·0 in such volume that the final liquid contained 15 per cent water. The debris was filtered off and enough acetone added to the filtrate to reduce the water content to 4–6 per cent. A precipitate was formed which was filtered off, washed with a little acetone and dissolved in distilled water + sodium hydroxide to *p*H 8·0. This treatment when applied to mammalian anterior pituitaries yields an extract containing almost all the hormonal material present. No attempt was made to purify the material further.

Exp. 1. The extract from 230 specimens of *Phallusia* was injected into three female mice aged 26 days, so that each received six injections of 0·5 ml. within 48 hr. Each mouse received 3·0 ml., representing the extract derived from 75 specimens of *Phallusia*. The controls—unfortunately only two, since one died during the experiment—received injections of an extract prepared from the same weight of other body tissues of *Phallusia* by the same method. The mice were sacrificed 96 hr. from the start of the experiment. The ovaries were weighed in pairs, fixed in corrosive-formal, and stained, after sectioning, in Ehrlich's hæmatoxylin. The ova above a certain arbitrary limit of size (1 division of an uncalibrated eyepiece micrometer) were counted in each ovary in sections at every 80 μ. The weights of the pairs of ovaries in the experimental animals were 13, 14 and 9 mgm. (average 12 mgm.); in the controls, 2½ and 6 mgm. (average 4½ mgm.). The number of large ova in the experimental animals was 71, 93, 101, 82, 77, 64 (average 81·2); in controls, 40, 23, 37, 30 (average 32·5). In the experimental animals, the beginning of follicular maturation were apparent in spaces appearing between the cells; and the largest follicles were visible to the naked eye in the fresh dissection. In the ovaries of the controls, there were no such spaces, and the ovaries appeared quite smooth. Fallopian tubes were developed further in experimental animals than in the controls.

Exp. 2. The extract derived from 120 *Ciona* was injected into the dorsal lymph-sac of three male toads in a single dose each. The same individuals were afterwards used as controls, receiving injections of an extract of other body tissues of *Ciona*. The positive response to this test is the appearance of sperm in the cloacal fluid. The results may be summarized thus:

0 hr. All −.	Injection	72 hr. All −.	Control Injection
6 hr. All −.		78 hr. All −.	
9 hr. 1 +, 2 −.		81 hr. All −.	
20 hr. 2 +, 1 −.		92 hr. All −.	

An extract of the neural region of *Ciona* has caused sperm release in two out of three toads when injected in a dose equivalent to 40 specimens into each toad. An extract of the rest of the body of *Ciona* produced no such response.

We may conclude that a gonadotrophically active substance can be extracted from the complex 'ganglion–neural gland–ciliated pit' of *Ciona* and *Phallusia*, and presumably of Ascidians in general, but not from the rest of the body. Hogg's conclusions are confirmed. As a further confirmation that a gonadotrophin may play some part in the natural biology of the Ascidian, I may add that I have observed that an injection of chorionic gonadotrophin into *Phallusia* or *Ciona* stimulates ovulation.

This work was carried out in the Zoological Station of Naples while holding the Oxford Naples scholarship, a senior demyship of Magdalen College, Oxford, and a Beit Memorial fellowship for medical research.

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[1] Butcher, E. O., *J. Exp. Zool.*, **57**, 1 (1930).
[2] Bacq, Z. M., and Florkin, M., *Arch. Internat. Physiol.*, **40**, 442 (1935).
[3] Pérès, J. M., *Ann. Inst. Oceanograph.*, **21**, 229 (1943).
[4] Hogg, B. M., *Proc. Soc. Exp. Biol. Med.*, **35**, 616 (1937).

Acute Action of Goitrogenous Agents on the Body Temperature and Oxygen Consumption of the Rat

IT has been demonstrated with rats that a single subcutaneous injection of aminothiazole (0·01–0·02 gm.), methylthiouracil (0·03–0·07 gm.) or methylsulphathiazole (0·03–0·05 gm.) is followed by a fall in body temperature and, after an occasional initial rise, by a marked decline in oxygen consumption. These effects are even more marked in the thyroid-

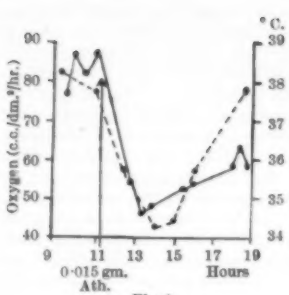

Fig. 1

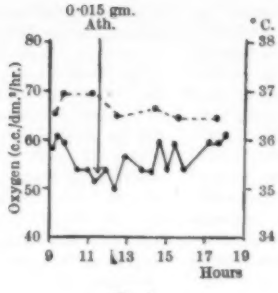

Fig. 2

Fig. 1. Rat 254·190 gm., male. Operation January 13, 1950. Electrodes introduced into hypothalamus, but no current was passed. Aminothiazole experiment performed on January 28, 1950

Fig. 2. Rat 256·110 gm., male. Thyroidectomy, January 13, 1950. Bilateral lesion of hypothalamus, January 15, 1950. Aminothiazole experiment performed on February 4, 1950

●- - -●, body temperature
●——●, oxygen consumption

ectomized or hypophysectomized animal[1,2]. During the fully developed action of aminothiazole, a decrease of environmental temperature from 29° to 21° C. fails to evoke a rise in oxygen consumption in the rat. The action of α-dinitrophenol on oxygen consumption is not impaired by aminothiazole. Section of the thoracic cord has no effect on the acute action of aminothiazole on body temperature and oxygen consumption; but, after section of the cervical cord, aminothiazole has no effect on body temperature and causes a transitory rise, instead of a fall, in oxygen consumption[2].

These observations suggested that the acute action of goitrogenous agents on oxygen consumption may be of central nervous origin. Therefore, using the Horsley–Clarke stereotactic instrument, bilateral electrolytic lesions were made in the hypothalamus of the rat. Fig. 1 demonstrates a normal response to aminothiazole in a sham-operated animal (no current passed through the electrodes), and Fig. 2 shows the typical absence of a response in an animal with bilateral lesions in the posterior part of the hypothalamus.

All animals in which the hypothalamic lesion was associated with a marked disturbance of thermo-regulation failed to respond to aminothiazole. In a few instances, in animals in which the disturbance of thermo-regulation was not gross, an isolated effect on body temperature or oxygen consumption was observed. It would appear, therefore, (1) that the acute action of aminothiazole on oxygen consumption involves a central nervous mechanism in which the hypothalamus plays an essential part, and (2) that the effects on body temperature and oxygen consumption are not strictly linked, as these may be abolished either independently or together by lesions not severely impairing thermo-regulation.

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[1] Balogh, L., Donhoffer, Sz., Jilly, P., and Mestyán, Gy., *Kisérletes Orvostudomány*, **2**, 51 (1950).
[2] Mestyán, Gy., and Barka, I. (in the press).
[3] Balogh, L., Barka, I., Donhoffer, Sz., Jilly, P., and Mestyán, Gy. (in the press).

Hydroxytyramine in Mammalian Heart

Extracts of mammalian hearts have been shown to contain adrenaline[1,2] and *nor*adrenaline[3,4]. Hitherto there has been no indication of other catechol substances in mammalian heart. However, hydroxytyramine occurs in urine[5,6], and has recently been found in sheep suprarenals[7].

When extracts of sheep hearts were concentrated and subjected to paper chromatography, three catechol spots were observed. As to colour and position, they were comparable to known solutions of adrenaline, *nor*adrenaline and hydroxytyramine. This identity was substantiated by exposing the extract chromatogram to two different solvent systems, namely, *n*-butanol / *N* hydrochloric acid[8] and phenol/water[9].

In addition, this extract was run through a starch column with *n*-butanol/*N* hydrochloric acid as solvent, for identification by fractionation[8]. The column was run for approximately eighty hours with each fraction representing one hour. The *R*-values are given in the accompanying table. The *R*-values obtained with sheep heart extract correspond to the results obtained from pure solutions of hydroxytyramine, adrenaline and *nor*adrenaline run over an equivalent period.

R-Values obtained by Chromatographic Separation of Adrenaline *Nor*adrenaline and Hydroxytyramine on Starch using *n*-Butanol/*N* Hydrochloric Acid as a Solvent

Exp.	Amounts of added substances	*R*-values		
		Hydroxy-tyramine	Adrena-line	*Nor*-adrenaline
1	2,080 μgm. hydroxytyramine + 620 μgm. adr.-HCl + 640 μgm. DL-*nor*adr.-HCl	0·328	0·247	0·155
2	505 μgm. hydroxytyramine + 430 μgm. adr.-HCl + 610 μgm. DL-*nor*adr.-HCl	0·313	0·222	0·136
3	Sheep heart extract*	0·347	0·236	0·146

* The extract was prepared for the column by distillation with *n*-butanol[9].

Each group of these fractions was tested biologically, colorimetrically and chromatographically, and in all cases was comparable to known solutions of hydroxytyramine, adrenaline and *nor*adrenaline.

The presence of hydroxytyramine in normal sheep heart is suggestive of the role that hydroxytyramine may have as a precursor of *nor*adrenaline[5,10].

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[1] Loewi, O., *Pflüg. Arch. ges. Physiol.*, **237**, 504 (1936).
[2] Cannon, W. B., and Lissák, K., *Amer. J. Physiol.*, **125**, 765 (1939).
[3] Euler, U. S. v., *J. Physiol.*, **105**, 38 (1946).
[4] Goodall, McC., *Acta Physiol. Scand.*, **20**, 137 (1950).
[5] Holtz, P., Credner, K., and Kroneberg, G., *Arch. exp. Path. Pharm.*, **204**, 228 (1947).
[6] Euler, U. S. v., and Hellner, S. (to be published).
[7] Goodall, McC., *Acta Chem. Scand.*, **4**, 550 (1950).
[8] Hamberg, U., and Euler, U. S. v. (in the press).
[9] James, W. O., *Nature*, **161**, 851 (1948).
[10] Blaschko, H., *J. Physiol.*, **101**, 337 (1942).

Phenol Oxidases of the Cultivated Mushroom *Psalliota bispora f. albida*

THE mycelia of certain wood-rotting and litter-decomposing Hymenomycetes form enzymes of the laccase type[1]. I have shown that the mycelium of *Marasmius graminum* produces a copper-containing phenol oxidase of the same type. This enzyme catalyses the oxidation of polyphenols and aromatic diamines, the oxidation of *p*-phenylenediamine being much faster than that of catechol. It is not poisoned by carbon monoxide[2]. The fruit-bodies of the cultivated mushroom, *Psalliota bispora f. albida* (= "*Ps. campestris*"), contain a polyphenol oxidase which oxidizes catechol but not *p*-phenylenediamine and which is inhibited by carbon monoxide[3]. Provided that the mycelium of *Ps. bispora* contains the same carbon monoxide – sensitive oxidase, it should be possible to clarify the problem of whether the phenol oxidases of these fungi act as terminal respiratory enzymes. This might be done by studying the influence of carbon monoxide on the respiration of the mycelia. The respiration of the *Psalliota* mycelium ought to be sensitive to carbon monoxide whereas that of *Marasmius* ought to be insensitive. Therefore, the mycelia of both fungi were grown in Barcroft vessels, and the influence of carbon monoxide on the respiration was determined. Respiration was not inhibited in either of the two fungi.

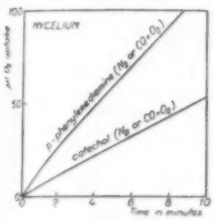

Fig. 1

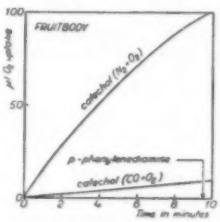

Fig. 2

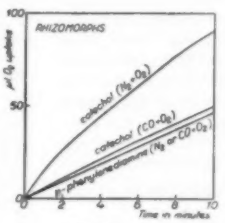

Fig. 3

Effect of carbon monoxide on the oxidation of catechol and *p*-phenylenediamine by enzyme extracts from mycelium, fruit-body, and rhizomorphs of *Psalliota bispora f. albida*

The phenol oxidase of the *Psalliota* mycelium was investigated further. The mycelium was grown on the following nutrient solution: glucose, 10 gm.; asparagine, 1 gm.; $MgSO_4.7H_2O$, 0·5 gm.; KH_2PO_4, 0·45 gm.; Na_2HPO_4, 0·47 gm.; Ca, 20 p.p.m.; Mn, 2·7 p.p.m.; Fe, Zn and Cu, 1 p.p.m.; aneurin, 50 γgm.; yeast extract, 100 mgm.; distilled water to 1,000 ml. (cf. Treschow[4]). After five weeks, the mycelium was collected from the flasks, washed and ground with sand after addition of $M/10$ phosphate buffer, *p*H 6·8. The extract was centrifuged and filtered. The filtrate was saturated with ammonium sulphate, and the precipitate was collected by centrifuging at high speed, dissolved in a small quantity of water and dialysed.

When cultivated in composts, *Ps. bispora* forms rhizomorphs, that is, strings of hyphæ which transport substances from the absorbing mycelium to the fruit-bodies. Extracts from rhizomorphs and from fruit-bodies were prepared in the same way as from the mycelium.

The ability of the three enzyme extracts to catalyse the oxidation of catechol and *p*-phenylenediamine and the influence of carbon monoxide on these oxidations were studied in Barcroft manometers. Experiments were run in 90 per cent nitrogen + 10 per cent oxygen and in 90 per cent carbon monoxide + 10 per cent oxygen. The following system was used: 5 mgm. catechol or *p*-phenylenediamine, a suitable amount of enzyme extract, $M/10$ phosphate buffer *p*H 6·8 to a final volume of 3·3 ml. (see graphs).

The mycelium extract catalysed the oxidation of *p*-phenylenediamine and catechol, the oxidation of the diamine being about twice as fast as that of catechol. The enzyme was not influenced by carbon monoxide. Thus, the mycelium contains an enzyme of the laccase type.

The extract from the fruit-body oxidized catechol but not *p*-phenylenediamine. It was strongly inhibited by carbon monoxide.

From the rhizomorphs, finally, an extract was obtained which, like that of the mycelium, catalysed the oxidation of *p*-phenylenediamine and catechol. However, the oxidation of the catechol was faster than that of the diamine. Furthermore, the oxidation of the catechol was partly inhibited by carbon monoxide, whereas the oxidation of *p*-phenylenediamine was not influenced by this gas. These results may be interpreted as follows. The oxidation of the *p*-phenylenediamine was due to laccase, which is not influenced by carbon monoxide. The oxidation of the catechol was partly due to the same laccase and partly to polyphenol oxidase, which is sensitive to carbon monoxide and which is of the same type as that occurring in the fruit-bodies.

Thus, with *Ps. bispora f. albida* the mycelium produces laccase and the fruit-bodies produce a carbon monoxide – sensitive polyphenol oxidase, whereas in the rhizomorphs a mixture of both enzymes is formed.

I am indebted to Prof. D. Keilin and Dr. T. Mann for their help and advice. This work was supported by a grant from the Swedish Natural Science Research Council.

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[1] Fåhraeus, G., *Ann. Roy. Agric. Coll. Sweden*, **16**, 618 (1949).
[2] Lindeberg, G. (unpublished results).
[3] Keilin, D., and Mann, T., *Proc. Roy. Soc.*, B, **125**, 187 (1938).
[4] Treschow, C., Diss. Copenhagen, 1944.

High Toxicity of Pure Botulinum Type *D* Toxin

CULTURES of *Clostridium botulinum* Type *D* were grown in intussuscepted 'Cellophane' tubes[1-3]. Ammonium sulphate to 40 per cent saturation was added to the filtered dialysed culture and the *p*H adjusted to 5·8. The slight precipitate which formed immediately after the solution of the ammonium sulphate was found to contain most of the toxin, and was re-dissolved and precipitated at between 25 and 30 per cent saturation at *p*H 5·8. Subsequent precipitations were carried out at between 25 and 30 per cent saturation with ammonium sulphate, depending on the results of toxicity tests and nitrogen determinations. Purification was continued until the toxin was electrophoretically homogeneous. Diffusion measurements, however, showed that the material was polydisperse, and that the major part diffused at a rate consistent with an average molecular weight of about a million.

The toxicity was measured by injecting appropriate dilutions of the botulinum Type *D* toxin into 20-gm. white mice, eight mice, as a rule, being used for each dilution. There was little difference between the results of subcutaneous or intraperitoneal injection. When the toxin was diluted in 0·2 per cent gelatin in phosphate buffer at *p*H 6·2, the very high toxicity of 4×10^{12} m.l.d./mgm. protein nitrogen was obtained. The gelatin – phosphate diluent was very similar to that used by Lamanna *et al.*[4] and Abrams *et al.*[5] in establishing the titre of pure botulinum Type *A* toxin.

This diluent, as well as others tried, appeared to have a 'potentiating' action on the toxin similar to that described by Traub *et al.*[6]. One of us (M. S.) has suggested that this might be due to a disaggregation of the toxin into smaller active units. Svedberg and Pedersen[7], as well as a number of other workers, have discussed the dissociation of proteins under the influence of other proteins, amino-acids and simple inorganic ions.

Lamanna *et al.*[4] and Abrams *et al.*[5] found that pure botulinum Type *A* toxin diluted in gelatin – phosphate had a toxicity for mice of 220×10^6 m.l.d./mgm. protein nitrogen. Botulinum Type *D* toxin, under similar conditions, appeared to be up to 20,000 times as toxic for the mouse as pure Type *A* toxin.

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[1] Polson, A., and Sterne, M., *Nature*, **158**, 238 (1946).
[2] Wentzel, L. M., and Sterne, M., *Science*, **110**, 259 (1949).
[3] Sterne, M., and Wentzel, L. M., *J. Immunol.*, **65**, 175 (1950).
[4] Lamanna, C., McElroy, O. E., and Eklund, H. W., *Science*, **103**, 613 (1946).
[5] Abrams, A., Kegeles, G., and Hottle, G. A., *J. Biol. Chem.*, **164**, 63 (1946).
[6] Traub, F. B., Hollander, A., and Friedemann, U., *J. Bact.*, **52**, 169 (1946).
[7] Svedberg, T., and Pedersen, K. O., "The Ultracentrifuge" (Clarendon Press, Oxford, 1940).

A Unit of Penicillinase

The presence of the enzyme penicillinase in extracts of *B. coli* and other micro-organisms was first described by Abraham and Chain[1]. Later, a unit of penicillinase potency was proposed, by McQuarrie, Liebmann, Kluener and Venosa[2]. Since that time several groups of investigators have studied this enzyme[2–11] and defined their own relative units of activity. This was justified by the fact that no pure crystalline product suitable as a reference standard was available. The definitions of these units are all based on arbitrary experimental conditions of inactivation and techniques of penicillin assay, and thus do not permit interconversion. Moreover, the majority of the techniques used are based on penicillin inactivation at the lower ranges of concentrations at which the rate of destruction is a function of both the penicillinase concentration and the penicillin concentration, while the latter is decreasing during the experiment.

It has been our endeavour to determine the conditions under which the analysis of penicillinase activity can be made independent of the technique employed in determining the amount of penicillin inactivated. On this basis a definition of a unit of potency is proposed which is similar in magnitude to the original unit of McQuarrie *et al.*[2].

To achieve this the following conditions were found essential: (1) inactivation of penicillin should be negligible in the absence of the enzyme; (2) rate of inactivation should be proportional to the enzyme concentration; (3) rate of inactivation should be independent of the concentration of penicillin.

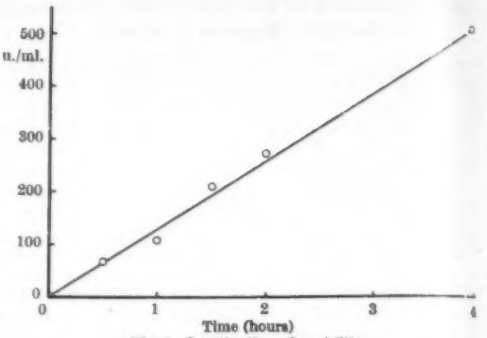

Fig. 1. Inactivation of penicillin

This last stipulation is fulfilled over a wide range of penicillin concentration. Wise and Twigg[11] found this to be the case at about 200 u./ml., Henry and Housewright[7] around 1,000 u./ml., and we tested the hydrolysis at concentrations up to 60,000 u./ml. and found the reaction-rate to be independent of the penicillin concentration. Under these conditions the second requirement is also fulfilled, namely, the reaction-rate is inversely proportional to the dilution of the enzyme preparation within the practical range of operation, requiring a few minutes to a few hours for the bulk of the penicillin present to be inactivated. To satisfy the first requirement it is necessary to conduct the reaction at a *p*H not exceeding 7·0 and at room temperature, even though these conditions do not represent exact maxima of penicillinase activity. Additional points of importance for a definition which is free of ambiguity is the nature of the buffer and the absence of chance impurities in the substrate[7,11]. Furthermore, the nature of the penicillin salt may also have some influence[7].

When all these conditions are properly considered, the observation of the penicillinase activity is truly independent of the testing technique. The manometric method[7] or the alkalimetric method[11] cited may be suitable. In addition we developed three unrelated methods, a polarimetric and an iodometric titration method, both of which we intend to describe in detail elsewhere, and a microbiological method which is used in the following as an illustration.

A solution of potassium benzylpenicillin (purity 1,530 u./mg.) in 0·1 *M* phosphate buffer at *p*H 7·0 was prepared containing about 3,500 u./ml. 1-ml.

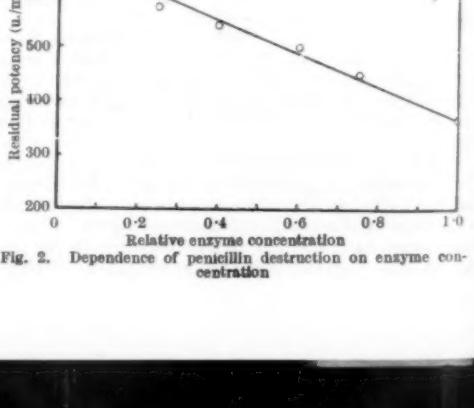

Fig. 2. Dependence of penicillin destruction on enzyme concentration

portions of a penicillinase stock solution prepared with 0·1 *M* phosphate buffer were added to 20-ml. aliquots of this solution. After a predetermined time the penicillin remaining was extracted as follows. The sample was rapidly acidified with phosphoric acid (50 vol. per cent) to *p*H 2·3 using a glass-electrode *p*H meter and immediately extracted with two 20-ml. portions of ice-cold amyl acetate. The combined amyl acetate portions were re-extracted with two portions of 40 ml. of 0·2 *M* phosphate buffer at *p*H 7·0 and made up to 100 ml. Controls, to which the penicillinase was added immediately before extraction, were also prepared and all extracts were assayed for penicillin by a turbidimetric, *S. aureus*, microbiological assay method. The assay values were subtracted from the values found in the controls (the controls showed a loss of only about 1·5 per cent of activity per hour). These are the values which are plotted in Fig. 1. The independence of the reaction-rate of the penicillin concentration, that is, a typical zero-order reaction-rate, is obvious. The validity of these data depends on the completeness of the extraction procedure, which was tested previously[11], and the precision of the assay, which is of the order of ± 5 per cent.

As mentioned before, under the conditions described, the rate of inactivation is proportional to the enzyme concentration. This is illustrated by the following experiment. To a stock solution, prepared as the one described above, aliquots of a penicillinase solution were added. After exactly one hour these samples were extracted as described. The potencies found are plotted (together with that of the original solution) in Fig. 2, showing the proportionality of the inactivation to the enzyme concentration.

Essentially identical results were obtained with both the polarimetric and the iodometric procedure, and similar results by the two other techniques cited[7,11]. Hence the validity of our postulates seems established.

Therefore our definition is:

A unit of penicillinase effects the inactivation of 10^{-7} moles of penicillin (35·6 mcg. or 59·3 units of sodium benzylpenicillin) per hour at 25° C. at *p*H 7·0. This action takes place in a phosphate buffered solution of a pure alkali salt of benzylpenicillin in sufficient concentration to maintain a zero-order reaction-rate.

The technical assistance of members of these Laboratories, particularly that of Mr. David Fergus, is gratefully acknowledged. Thanks are expressed to Dr. B. Puetzer and Dr. K. Lædenburg for encouragement and to Schenley Laboratories, Inc., for permission to publish this communication.

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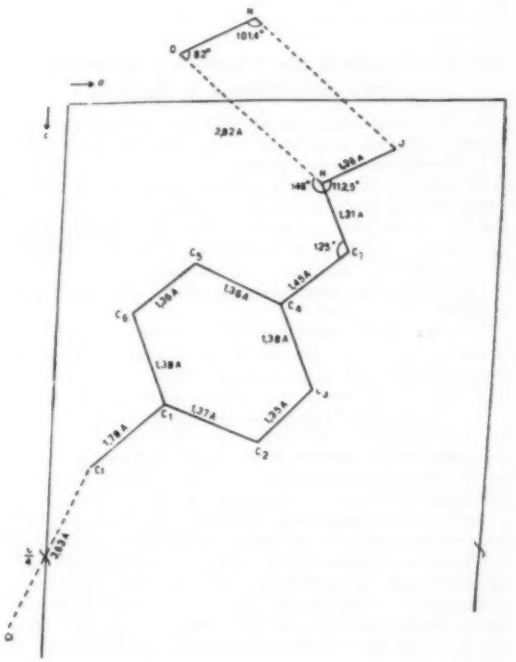
[1] Abraham, E. P., and Chain, E., *Nature*, **146**, 837 (1940).
[2] McQuarrie, E. B., Liebmann, A. J., Kluener, R. G., and Venosa, A. T., *Arch. Biochem.*, **5**, 307 (1944).
[3] Benedict, R. G., Schmidt, W. H., and Coghill, R. D., *Arch. Biochem.*, **8**, 1377 (1945).
[4] Perault, R., *C. Rend. Soc. Biol.*, **139**, 580 (1945).
[5] Proom, H., *Brit. J. Exp. Path.*, **26**, 98 (1945).
[6] LePage, G. A., Morgan, J. F., and Campbell, M. E., *J. Biol. Chem.*, **166**, 465 (1946).
[7] Henry, R. J., and Housewright, R. D., *J. Biol. Chem.*, **167**, 559 (1946).
[8] Grumbach, B., Sureau, B., and Boyer, F., *Amer. Inst. Pasteur*, **74**, 12 (1948).
[9] Gibian, H., *Z. Bakt. Parasitenk.*, I Abt. orig., **152**, 527 (1948).
[10] Gunderson, I. O., *Pharm. Acta Helv.*, **24**, 77 (1949).
[11] Wise, W. S., and Twigg, G. H., *Analyst*, **75**, 106 (1950).
[12] Levy, G. B., Fergus, D., and Caldas, J. M., *Anal. Chem.*, **21**, 664 (1949).

Crystal Structure of *syn* *p*-Chlorobenzaldoxime

As a first step in the survey of several oxime structures, the crystal structure of *syn* *p*-chlorobenzaldoxime has been examined by X-ray analysis. So far, no detailed crystallographic data on an oxime have been published; the results now obtained are interesting on account both of oxime stereochemistry and of the actual inter-atomic distances present, both intra- and inter-molecular.

syn *p*-Chlorobenzaldoxime was prepared by the method of Erdmann and Schwechten[1]; after re-crystallization from alcohol or benzene, the melting point was 109½–110½° (110° litt.). The crystals are monoclinic needles, elongated along the *b* axis. The space-group is $P2_1/c$; $a = 6{\cdot}06$ A., $b = 4{\cdot}73$ A., $c = 25{\cdot}0_6$ A., $\beta = 93{\cdot}4°$ (copper $K_{\alpha 1} = 1{\cdot}5405$ A.), $n = 4$. The intensities of the X-ray reflexions were estimated visually from Weissenberg photographs, the multiple-film technique being used. The crystal structure was established by the calculation of Patterson projections, *Puw* and *Pvw*, followed by successive refinements of the corresponding electron density projections, ρxz and ρyz. From these, which were both well-resolved projections, the co-ordinates of all the atoms in three dimensions could be assigned. Based on these co-ordinates, the discrepancy between observed and calculated structure factors, $\Sigma \big| |F_{obs.}| - |F_{calc.}| \big| / \Sigma |F_{obs.}|$ was 21·7 per cent and 18·4 per cent for the reflexions (*h*0*l*) and (0*kl*) respectively, non-observed reflexions included.

The atomic arrangement found is illustrated in the accompanying diagram, which shows part of the crystal structure viewed along the *b* axis; inter-atomic distances are given in this diagram, as well as the magnitude of some bond angles. It is possible



that these will be changed a little when the three-dimensional electron density distribution is calculated. However, exactly the same C—N distance, 1·31 A., and N—O distance, 1·36 A., have recently been found in acetoxime by Bierlein and Lingafelter[2]. So far, no other comparable C—N distance has been observed; the N—O distance, as might be expected, is appreciably shorter than the corresponding distance in hydroxylamine hydrochloride which was found[3] to be 1·45 A.

The chlorine atom and all the carbon atoms of the aldoxime molecule are situated very nearly in a plane, the deviations from an approximating plane being ± 0·03 A. or less, except for C_1, which deviates − 0·06 A. The N—O group is tilted a little out of this plane, the distance from the approximating plane to the nitrogen atom being − 0·31 A., and from the oxygen atom − 0·19 A. The molecules make two kinds of contact with each other in the direction of the *c*-axis. The chlorine atoms of neighbouring molecules, which are related by the screw axes, make van der Waals' contacts, the Cl—Cl distance being 3·63 A. The molecules related by the centres of symmetry are grouped in pairs by much shorter distances, 2·82 A. between the nitrogen and oxygen atoms of the two neighbouring molecules. It is impossible yet to say what part the hydrogen atoms play in this system; their position may become clear in the three-dimensional electron density distribution which is now being calculated.

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[1] Erdmann, H., and Schwechten, E., *Ann.*, **260**, 63 (1890).
[2] Bierlein, T. K., and Lingafelter, E. C., "The Crystal Structure of Acetoxime". Paper presented at the Amer. Cryst. Assoc. meeting, April 1950.
[3] Jerslev, B., *Acta. Cryst.*, **1**, 21 (1948); *Nature*, **160**, 641 (1947).

A New Method for Measuring Velocities of Ultrasonic Waves in Liquids

Ultrasonic velocities in liquids determined by various methods have been reported in the literature. The interferometer method[1], though widely adopted by a number of workers, permits velocity measurements only at low ultrasonic frequencies. The Debye–Sears's diffraction method[2] and the Hiedemann method[3] of visibility are applicable only for the study of transparent liquids. Elaborate technique is required for velocity determinations by the pulse method[4].

In the method described here, a small liquid cell is constructed by cementing two thin cover-glass slips on either side of an annular brass disk of uniform thickness (2·48 mm.) and inside diameter of about 1 cm. A side hole is provided for the purpose of introducing liquids in the space enclosed by the cover-slips, which can be completely filled up by about 0·25 c.c. of liquid forming, as it were, a liquid plate of thickness 2·5 mm. Ultrasonic waves generated by a wedge are transmitted through this liquid plate and communicated to water contained in a glass trough which serves as the ultrasonic cell for obtaining the Debye–Sears's diffraction pattern. Resonance frequencies of this liquid plate are determined in the usual manner employing the wedge method[5]. The low order of the fundamental resonance frequency of the liquid plate enabled a number of transmission maxima to be obtained at close intervals with a single wedge of frequency-range 3–6 Mc./sec. Using this set of transmission frequencies, the fundamental frequency and hence the velocity of sound in the liquid contained in the cell are evaluated. Results thus obtained for the velocities of sound in some liquids are shown in the accompanying table, along with those obtained by some of the other methods.

	Fundamental frequency (Mc./s.)	Velocity calculated in metres per sec. at 30° C.	Velocities obtained by other methods (23–27° C.)
Glycerine	0·390	1,950	1,986 (ref. 6)
Water	0·304	1,520	1,500 (ref. 6)
Mercury	0·285	1,425	1,440 (ref. 7)
Toluene	0·260	1,300	1,300 (ref. 6)
Ethyl alcohol	0·231	1,155	1,150 (ref. 6)
Carbon tetrachloride	0·181	905	930 (ref. 6)

The method is simple, rapid and highly accurate, being particularly suitable for liquids, both opaque and transparent, available only in very small quantities. In addition, it permits measurements of velocities over a wide range of frequencies. Further detailed investigations are in progress.

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[1] *Phil. Mag.*, **5**, 1177 (1928).
[2] *Proc. U.S. Nat. Acad. Sci.*, **18**, 409 (1932).
[3] *Nature*, **133**, 176 (1934).
[4] *J. Chem. Phys.*, **14**, 608 (1946).
[5] *Proc. Ind. Acad. Sci.*, **20**, 298 (1944).
[6] *J. Acous. Soc. Amer.*, **12**, 438 (1941).
[7] *Phys. Rev.*, **72**, 87 (1947).

Abnormal Efficiencies in the Scintillation-counting of Gamma-Rays

In an earlier communication, Mayneord and Belcher[1] have shown that, under appropriate conditions of high gain and low pulse-discrimination, the counting-rates for scintillations observed in a small calcium tungstate crystal irradiated by gamma-radiation approximate to the rates of absorption of gamma-ray quanta in the crystal calculated from theoretical linear absorption coefficients.

Similar observations on small crystals of thallium-activated potassium iodide show, however, that the counting-rates in this material may be many times greater than the calculated absorption-rates. This anomalous behaviour of thallium-activated potassium iodide, first reported by Freedman, Smaller and May[2], has been studied using experimental arrangements identical to those already described[1].

Fig. 1 shows the ratios, *R*, of the observed maximum counting-rates to the calculated rates of absorption of gamma-quanta derived from Klein–Nishina, Fowler–Hulme and Heitler theories, plotted as a function of crystal mass for crystals of equal cross-section, but varying thickness. Appropriate corrections have been made for background effects and scaler dead-time. Measurements were made for the gamma-radiation from various radioisotopes.

It will be seen that the observed rates are considerably greater than those calculated, and that the ratio of the two increases with increase in energy of

the exciting radiation. Further studies have shown that this effect is due to electron-trapping levels in the luminophor lattice; each gamma-quantum absorbed may thus produce a delayed phosphorescent emission consisting of single photons, in addition to a short-duration fluorescent pulse containing many photons. Of these single photon pulses, a fraction, determined by the resolving time and optical efficiency of the system, will be recorded in the counter.

We may expect that the number of phosphorescent centres excited by a single gamma-quantum absorbed in the crystal will depend on the energy of its secondary electron, and indeed will be linearly proportional to this energy. This is confirmed in Fig. 2, where the ratio, R, of observed to calculated counting-rates for various radioisotopes in a crystal of mass 0·126 gm. is plotted against the calculated mean energy, $\bar{E}_s$, of the secondary electrons produced in the crystal. As expected, the experimental values fall approximately on a straight line, which when extrapolated intersects the vertical axis at unity, showing that the number of phosphorescent pulses, $R - 1$, counted for each quantum absorbed is linearly proportional to $\bar{E}_s$. The slight deviation from linearity in the case of the high-energy radiation of sodium-24 may be interpreted as being due to the escape from the crystal of some of the more energetic secondary electrons produced by this isotope before they have expended all their energy in exciting phosphorescent centres; the fall in the ratio of observed to calculated counting-rate apparent in Fig. 1 in the case of the smallest crystal studied may also be explained in terms of this effect.

Studies on the effect of scaler resolving time on counting-rate in thallium-activated potassium iodide show that the phosphorescent emission obeys a non-exponential decay law; it falls to half its initial value in 2·5 msec., but persists for many minutes after the initial excitation event. Further observations on synthetic calcium tungstate indicate that this material also shows an impurity-activated phosphorescent emission, but of low intensity and of short duration. The decay in this case appears exponential, with a half-life of 20 μsec. (to be compared with the approximate figure of 100 μsec. quoted by Garlick[3]). Thus, it is not appreciable at counter resolving times greater than 100 μsec. Samples of purified anthracene and of anthracene-activated naphthalene have also been examined; but contrary to the reports of Cross[4] no phosphorescent emission has been detected in the samples tested.

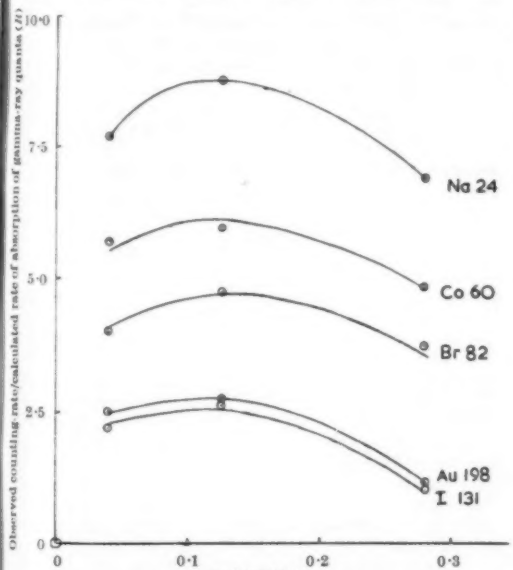

Fig. 1. Relationship between counting-rate and rate of absorption of gamma-ray quanta in thallium-activated potassium iodide. Resolving time, 10 μsec.; photo-multiplier voltage, 1,080; amplifier gain, 16,000

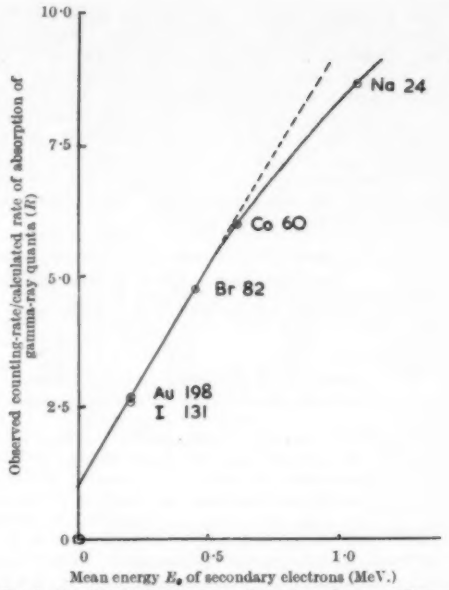

Fig. 2. Relationship between counting-rate and energy of secondary electrons in thallium-activated potassium iodide. Resolving time, 10 μsec.; photo-multiplier voltage, 1,080; amplifier gain, 16,000; mass of crystal, 0·126 gm.

Thanks are due to Mr. J. Sharpe, of the Atomic Energy Research Establishment, Harwell, for the gift of thallium-activated potassium iodide crystals, and to Dr. G. F. J. Garlick, of the University of Birmingham, for a sample of purified anthracene.

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[1] Maynecord, W. V., and Belcher, E. H., *Nature*, **165**, 930 (1950).
[2] Freedman, M., Smaller, B., and May, J., *Phys. Rev.*, **77**, 759 (1950).
[3] Garlick, G. F. J., "Luminescent Materials", 94 (Oxf. Univ. Press, 1949).
[4] Cross, W. G., *Phys. Rev.*, **78**, 185 (1950).

Cross-Linkage Formation in Keratin

When animal fibres, such as wool and hair, are treated with an acid solution of 3 : 4-*iso*propylidene 1 : 2·5 : 6-dianhydromannitol for 24 hr. at 50° C., cross-linkages are formed between the carboxyl groups of neighbouring peptide chains[1]. Since the fibres are then more resistant to deformation, their felting power is reduced, and attention has therefore been turned to the possibility of cross-linking wool with simpler di-epoxides, for example, 1 : 2·3 : 4-diepoxybutane (I) and 1 : 2·5 : 6-diepoxyhexane (II).

For this purpose, Lincoln wool fibres were purified by extraction with alcohol and ether, washed in distilled water, and then treated for 24 hr. at 50° C. with a 2·5 per cent solution of the di-epoxide in a phosphate buffer at the appropriate *p*H. After being washed in running water for 24 hr., the fibres were examined for the presence of new cross-linkages by determining the extent to which supercontraction could be induced by boiling for 30 min. in a 5 per cent solution of sodium metabisulphite[2]. The results are given in the accompanying table.

*p*H	Percentage supercontraction of fibres treated with		
	Buffer + I	Buffer + II	Buffer alone
4·44	0·0	29·6	26·4
6·12	0·0	23·6	26·6
7·05	0·3	23·5	26·5
7·87	1·3	19·7	26·5

Unlike fibres treated with buffer alone, those treated with an acid solution of I fail to supercontract, and it is obvious that the reagent is capable of forming new cross-linkages between the peptide chains of animal fibres. At first sight, therefore, it seems surprising that supercontraction should not be prevented by treatment with II, especially as a closely related compound—3 : 4-*iso*propylidene 1 : 2·5 : 6-dianhydromannitol—is known to cross-link keratin. Wiggins and Wood[3] have, however, shown that II gives a furan ring, and not a tetrahydroxy compound, on being boiled in water, and its failure as a cross-linking agent may well be due to ring formation after primary reaction with the carboxyl groups of wool.

We are indebted to the International Wool Secretariat for grants in aid of this investigation.

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[1] Capp and Speakman, *J. Soc. Dyers and Colourists*, **65**, 402 (1949).
[2] Speakman, *J. Soc. Dyers and Colourists*, **52**, 335 (1936); *J. Text. Inst.*, **38**, T102 (1947).
[3] Wiggins and Wood, *Nature*, **164**, 402 (1949).

Pyrophosphato-Complexes of Nickel and Cobalt in Solution

The literature on complex pyrophosphates of nickel and cobalt does not record any detailed study of their solutions. Rosenheim[1] observed that from solutions of alkali pyrophosphates containing nickel and cobalt pyrophosphates, the normal pyrophosphates separate unchanged. Later, Bassett and his co-workers[2] stated that nickel and cobalt pyrophosphates dissolve in excess of alkali pyrophosphates giving yellowish-green and purple solutions respectively, but they could not isolate any complex salt in the solid phase. This, however, does not show the non-existence of complex ions containing nickel or cobalt and pyrophosphate ion in solution. I have investigated complex formation in solution by different physico-chemical methods such as thermometric, transport, conductometric, *p*H measurements, cryoscopy in saturated sodium sulphate solutions and magnetic measurements.

Thermometric titration curves of alkali pyrophosphate solutions with nickel and cobalt salt solutions and vice versa indicate two breaks corresponding to the ratio of pyrophosphate to metal 2 : 1 and 1 : 1, which represent the formation of two complex ions with these ratios of the reactants. Breaks due to the normal pyrophosphates are also observed in the titration curves.

It is observed in transport measurements that the complex ion moves to the anode. This observation rules out the possibility of formulæ of the complex ion in which the ratio of pyrophosphate : metal is 2 : 1, namely,

$$[M(H_4P_2O_7)_2]^{+2} \text{ and } [M(H_3P_2O_7)_2],$$

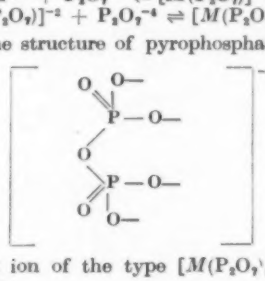
where M is nickel or cobalt. Conductivity titrations of alkali pyrophosphates with nickel and cobalt nitrate solutions confirm the thermometric results that two complex ions in which the ratio of pyrophosphate : metal is 2 : 1 and 1 : 1 are present in the solution. With the addition of nickel or cobalt nitrate solution, the conductivity of the alkali pyrophosphate solutions either decreases very slowly or remains practically constant up to the point where the ratio of pyrophosphate : metal is 2 : 1. This eliminates the formulæ $[M(H_3P_2O_7)_2]^{-2}$ and $[M(H_2P_2O_7)_2]^{-4}$ for the complex ion in which the ratio of pyrophosphate : metal is 2 : 1, otherwise free hydroxyl ions will be produced and the conductivity of the alkali pyrophosphate solutions will increase up to the point where the ratio pyrophosphate : metal is 2 : 1. Thus it is concluded that the complex ion is of the type $[M(P_2O_7)_2]^{-6}$. It may be supposed that the complex ion in which the ratio of pyrophosphate : metal is 1 : 1 has the formula $[M(P_2O_7)]^{-2}$.

*p*H titrations of sodium pyrophosphate solution with nickel or cobalt nitrate solution show a hump at the point pyrophosphate : metal equal to 2 : 1, corresponding to the complex ion $[M(P_2O_7)_2]^{-6}$.

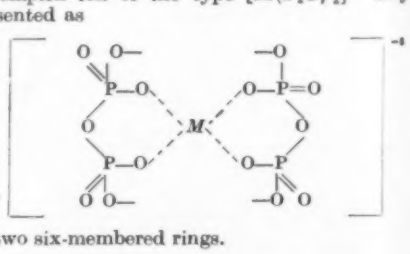
Cryoscopy measurements in saturated sodium sulphate solutions indicate that solutions in which the ratio pyrophosphate : metal is 2 : 1 contain almost half the total number of pyrophosphate ions used. That is, the complex ion $[M(P_2O_7)_2]^{-6}$ exists in simple monomeric form and the following equilibria exist in the solution:

$$M^{+2} + P_2O_7^{-4} \rightleftharpoons [M(P_2O_7)]^{-2}$$
$$[M(P_2O_7)]^{-2} + P_2O_7^{-4} \rightleftharpoons [M(P_2O_7)_2]^{-6}.$$

Assuming the structure of pyrophosphate ion to be



the complex ion of the type $[M(P_2O_7)_2]^{-6}$ may be represented as



with two six-membered rings.

The possibility of co-ordinating with two other oxygen atoms of each pyrophosphate radical is eliminated by the fact that the rings formed will be four-membered, which are not very stable, and the co-ordination number of nickel or cobalt will be eight, which has not yet been observed in any of their complex compounds. The usual co-ordination number of nickel and cobalt is six, so it is probable that the other two co-ordinating positions are occupied by water molecules. But nothing can be said with any certainty, for the hydration of the complex ions in solution is not definitely known. The complex ion of the type $[M(P_2O_7)]^{-2}$ can be represented in a similar way with a six-membered ring.

Magnetic susceptibility measurements with solutions containing sodium pyrophosphate and nickel or cobalt chloride give the effective magnetic moments of the complex ions $[Ni(P_2O_7)_2]^{-6}$ and $[Co(P_2O_7)_2]^{-6}$ as 3·281 and 4·937 Bohr magnetons respectively. These values indicate that the complex ions have ionic bonding.

The behaviour of pyrophosphato complexes of nickel and cobalt in solution is found to be similar to that of copper, the results of which I have already reported[3].

My thanks are due to Prof. P. B. Sarkar for his interest and laboratory facilities, and also to Prof. P. Ray for allowing me to take the magnetic measurements in his laboratory.

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Rosenheim, *Z. anorg. ind. allg. Chem.*, **153–4**, 125 (1936).
Sasett, Bedwell and Hutchinson, *J. Chem. Soc.*, Part II, 1412 (1936).
Haldar, B. C., *Science and Culture*, **14**, 340 (1949).

An Improved Method of Detecting Sugars on Paper Chromatograms

Most of the methods of detection of sugars depend upon the formation of furfurals by the treatment of the sugar with mineral acid or fairly strong organic acid (for example, trichloracetic acid), and subsequent formation of a coloured compound with an amine or a phenol. The most common faults of the reagents hitherto tried are: (1) a partial destruction of the paper, making it fragile; (2) a dark background colour; (3) poor distinction between the various classes of sugars.

To avoid the destructiveness of large quantities of mineral acid, we decided to try various phenols and amines with traces of hydrochloric acid. The use of very dilute aqueous hydrochloric acid or aqueous/alcoholic acid did not prove successful. Success was obtained, however, with solutions of phenols and amines in absolute alcohol to which small quantities of acid (0·1–0·5 ml. of 4 *N* hydrochloric acid) had been added. It was found later that improved results were obtained by decreasing the volatility of the reagent by the addition of *n*-butanol to the mixture. The best results were obtained with a β-naphthylamine spray of the following composition: absolute alcohol 50 ml., *n*-butanol 50 ml., 3·8 *N* hydrochloric acid 0·4 ml., water 0·2 ml., β-naphthylamine (pure) 0·1 gm., ferric sulphate 10 per cent solution, 1 drop. Spray evenly and dry at 160–170° for about ten minutes.

Fructose is the first to show and gives a bright yellow spot, changing to yellow-brown. This is characteristic of fructose and those oligosaccharides which yield fructose on hydrolysis. Methyl pentoses behave similarly, but give a duller yellow. The pentoses appear rather slowly and give a bright pink-red colour. Aldoses give a light brownish colour. The method gave positive results with the following sugars: *aldohexoses:* mannose, glucose, galactose; *ketohexoses:* fructose, sorbose; *pentoses:* arabinose, ribose, lyxose, xylose; *methyl pentoses:* rhamnose, fucose; *disaccharides:* maltose, cellobiose, lactose, melibiose, sucrose; *trisaccharides:* raffinose.

The paper is unaffected by the acid even at such a high temperature as 170° and the background colour is very pale.

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C_{18} Unsaturated Acids of Butterfat

It has been generally assumed that the C_{18} unsaturated acids of butterfat comprise mainly oleic acid with some octadecadienoic acid (3–5 per cent of the total fatty acids) and traces of octadecatrienoic acid (cf. Hilditch[1]). In this Laboratory the C_{18} unsaturated acids of New Zealand butterfat have been submitted to alkali isomerization using the technique of Hilditch, Morton and Riley[2], and it has been found that the octadecatrienoic acid content is of the same order as that of the octadecadienoic acid, as shown in the accompanying table.

Composition of the C_{18} unsaturated acids of butterfat
(Results expressed as a percentage of the total C_{18} unsaturated acids)

Sample	Octadecadienoic		Octadecatrienoic	
	Non-conjugated	Conjugated	Non-conjugated	Conjugated
New Zealand butterfat (churned 28/6/48). (Methyl esters sap. equiv. 295·7, iod. val. 94·0)	1·27	1·31	3·14	Trace
New Zealand butterfat (churned 14/3/49). (Methyl esters sap. equiv. 294·9, iod. val. 97·7)	4·63	0·51	2·83	0·05
English butterfat (Hilditch and Jasperson, ref. 3)	2·0	2·0	0·2	Trace

It is thought that the differences in octadecatrienoic acid content between the New Zealand and English butterfats examined may be due to differences in linolenic acid content of the diet, the English butterfat being possibly from animals which had been stall-fed, whereas the New Zealand butterfat is produced almost entirely from a pasture diet, the main fatty acid constituent being linolenic acid. From time to time investigators[2–5] have indicated the probable presence of traces of linolenic acid in butterfat, and more recently Mattsson[6], using spectroscopic measurements after alkali isomerization, has inferred the presence of substantial amounts (0·7–2·0 per cent) in Swedish butterfat. By fractional distillation of the methyl esters, Mattsson was able to attribute the observed absorption at 232 mμ and 268 mμ almost

entirely to C_{18} unsaturated acids. It is admitted, however, that it had not been definitely shown by isolation of pure hexabromide or of other derivatives that butterfat does contain linolenic acid.

In this Laboratory, by submitting butterfat acids to low-temperature crystallization from acetone at −50° C., followed by fractional distillation of the methyl esters, a concentrate of highly unsaturated C_{18} acids (iodine value 151·3) was obtained. Bromination of this concentrate under the conditions described by White and Brown[7] yielded hexabromostearic acid (m.p. 180–181°, not depressed on admixture with authentic hexabromostearic acid) in amounts corresponding with the presence of 14·02 per cent linolenic acid, as compared with 14·99 per cent obtained by the alkali isomerization technique of Hilditch, Morton and Riley[8]. There seems, therefore, little reason to doubt that the octadecatrienoic acid content of New Zealand butterfat consists almost entirely of linolenic acid. On the other hand, in agreement with the extensive researches of Hilditch[1] on English butterfat, it appears most improbable that the octadecadienoic acid of New Zealand butterfat is linoleic acid, as the ether-soluble, petroleum ether-insoluble bromides yielded no tetrabromostearic acid (m.p. 114°), even when submitted to recrystallization from hot petroleum-ether according to the technique of Hilditch and Shorland[9], by which it is possible to detect small amounts of added linoleic acid in admixture with other polybromides. These findings may be contrasted with those of White and Brown[7], who claim to have established in samples of butterfat that two-thirds to three-quarters of the octadecadienoic acid is ordinary linoleic acid. The detailed report of this work is awaited with interest.

It has been previously suggested[10] that animal fats may be divided into two classes, homolipoid and heterolipoid, according to whether or not their composition is readily affected by the incorporation of dietary fatty acids. Beef tallow[11] has been shown to contain not more than traces of linolenic acid, while the present investigation establishes the presence of appreciable amounts of linolenic acid in milk fat. It appears, therefore, that not only are there species differences in regard to the influence of the dietary fat upon the composition of the depot fat, but also that within a given species the various fats are affected in varying degrees by the composition of the dietary fat.

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[1] Hilditch, T. P., "The Chemical Constitution of Natural Fats", 116 (2nd edit., Chapman and Hall, London, 1947).
[2] Hilditch, T. P., Morton, R. A., and Riley, J. P., *Analyst*, **70**, 67 (1945).
[3] Hilditch, T. P., and Jasperson, H., *J. Soc. Chem. Indust.*, **64**, 109 (1945).
[4] Eckstein, H. C., *J. Biol. Chem.*, **103**, 135 (1933).
[5] Hilditch, T. P., and Jasperson, H., *J. Soc. Chem. Indust.*, **60**, 305 (1941).
[6] Mattsson, S., XIIth Int. Dairy Congress, Stockholm, Vol. 2, Sect. 11, p. 308 (1949).
[7] White, M. F., and Brown, J. B., *J. Amer. Oil Chem. Soc.*, **26**, 133 (1949).
[8] Hilditch, T. P., and Shorland, F. B., *Biochem. J.*, **31**, 1499 (1937).
[9] White, M. F., and Brown, J. B., *J. Amer. Oil Chem. Soc.*, **26**, 385 (1949).
[10] Shorland, F. B., *Nature*, **165**, 766 (1950).
[11] Knight, H. B., Jordan, E. F., jun., and Swern, D., *J. Biol. Chem.*, **164**, 1477 (1946).

Instantaneous Electron Transfer and Interaction Absorption

Isotopic exchange by electron transfer between complex ions containing an element in different oxidation states has been demonstrated for quite a number of elements. In some instances, such as:

$$[Fe(CN)_6]^{\equiv} + [Fe^*(CN)_6]^{\equiv} \rightleftharpoons [Fe^*(CN)_6]^{\equiv} + [Fe(CN)_6]^{\equiv}$$

the exchange is so rapid as to seem instantaneous[1]. Systems containing an element in two oxidation states sometimes exhibit abnormally deep and intense colorations. For example, crystals of $(NH_4)_2SbCl_5$, which are believed to contain the complex ions $[SbCl_6]^{2-}$ and $[SbCl_4]^-$, are jet black[2]. The coloration of both solid $(NH_4)_2SbCl_5$ and its solutions is so much more intense than that produced by the component complex ions separately that it is described as arising from interaction absorption.

An attempt has been made recently to test the hypothesis that there is a correlation between instantaneous exchange by electron transfer and interaction absorption[3]. The result was inconclusive, mainly because of the great difficulty of deciding whether any exchange involving radioactive isotopes is instantaneous or not. There is apparently no sure way of discovering whether an exchange involving radioisotopes occurs in solution before separation, or whether it occurs during the separation of oxidized and reduced forms of the complex ions[4].

Because it is possible to detect rapid electron transfer without any chemical or physical separation of oxidized and reduced forms, the system D-$[Os^{II}(dipy)_3]$ $(ClO_4)_2$ and L-$[Os^{III}(dipy)_3]$ $(ClO_4)_3$ lends itself to testing the hypothesis that rapid electron transfer is accompanied by interaction absorption. We have accordingly examined mixed solutions of $[Os^{II}(dipy)_3]$ $(ClO_4)_2$ and $[Os^{III}(dipy)_3]$ $(ClO_4)_3$ for interaction absorption in the region 7,000–4,000 A. In view of the high dilution of the solutions used (5×10^{-4} *M*), for which exchange was complete in less than 15 sec., it is perhaps not surprising that we failed to find any interaction absorption. Nevertheless, the failure does prove that there is no correlation between the two phenomena.

Since these experiments were completed, Bonner[5] has shown that even in solutions which exhibit interaction absorption (solutions containing trivalent and pentavalent antimony), electron transfer may be quite a slow process. Further evidence against the above hypothesis has been adduced by Pauling[6] in a discussion of the origin of the colour of crystals of $Cs_2Au_2Cl_6$, which are black. The existence in these crystals of two distinct complexes, namely, linear $[Au^{I}Cl_2]^-$ and square $(Au^{III}Cl_4)^-$, rules out the possibility that the intense colour is due to resonance of electrons among the metal atoms.

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June 26.

[1] Thompson, *J. Amer. Chem. Soc.*, **70**, 1045 (1948).
[2] Elliott, N., *J. Chem. Phys.*, **2**, 298 (1934).
[3] Whitney, J., Browne, C. I., McConnell, H., and Davidson, N., Brookhaven Conference Report, Chemistry No. 2, p. 196 (1948).
[4] Prestwood, R. J., and Wahl, A. C., *J. Amer. Chem. Soc.*, **71**, 3137 (1949).
[5] Bonner, N. A., *J. Amer. Chem. Soc.*, **71**, 3909 (1949).
[6] Pauling, L., *Chem. Eng. News*, **25**, 2970 (1947).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, October 30

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Projection- versus Direct-Viewing Television in the Home" (to be opened by Mr. W. T. Cocking).

Tuesday, October 31

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. J. R. Hulme: "Bermuda and the West Indies".

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. A. R. Aikman: "The Frequency Response Approach to Automatic Control Problems".

ROYAL ANTHROPOLOGICAL INSTITUTE (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 8 p.m.—Prof. W. E. Le Gros Clark, F.R.S., and Dr. L. S. B. Leakey: "The Miocene Apes of Kenya".

Wednesday, November 1

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. Ernest W. Goodale: "Celebrating a Great Centenary" (Inaugural Address).

UNIVERSITY OF LONDON (at Bedford College for Women, Regent's Park, London, N.W.1), at 5.15 p.m.—Sir David Brunt, F.R.S.: "Weather Lore" (Stevenson Lecture).

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, November 2

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Symposium on "Tropolones and Allied Compounds" (introduced by Prof. J. W. Cook, F.R.S.).

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. W. K. Burton and Mr. N. Cabrera: "Equilibrium Structure of Crystal Surfaces"; Mr. W. K. Burton, Mr. N. Cabrera and Mr. F. C. Frank: "A Theory of Growth of Real Crystals".

MINERALOGICAL SOCIETY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion of a Report on "The Education and Training of Electrical Technicians" (to be presented by Sir Arthur Fleming).

BRITISH INSTITUTION OF RADIO ENGINEERS, MERSEYSIDE SECTION (at the Electricity Board Service Centre, Whitechapel, Liverpool), at 6.30 p.m.—Mr. D. W. Heightman: "Propagation of Metric Waves beyond Optical Range".

CHEMICAL SOCIETY, NOTTINGHAM SECTION (joint meeting with the UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Lecture Theatre, The University, Nottingham), at 6.30 p.m.—Prof. C. W. Shoppee: "The Cortisone Problem".

CHEMICAL SOCIETY, BRISTOL SECTION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, in the Chemistry Department, The University, Bristol), at 7 p.m.—Dr. J. S. Anderson: "The Hahn Emanation Technique".

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 7 p.m.—Prof. R. A. Fisher, F.R.S.: "Creative Aspects of Natural Law" (Arthur Stanley Eddington Memorial Lecture).*

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-WESTERN SECTION (in the Reynolds Hall, College of Technology, Manchester), at 7.15 p.m.—Mr. W. R. Cooper: "Communication Cables".

INSTITUTION OF WORKS MANAGERS, BRISTOL BRANCH (at the Royal Hotel, Bristol), at 7.15 p.m.—Mr. J. C. W. Stead: "Time Study and Incentives".

Friday, November 3

CHEMICAL SOCIETY, ST. ANDREWS AND DUNDEE SECTION (joint meeting with the ST. ANDREWS UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Department, United College, St. Andrews), at 5 p.m.—Prof. J. N. Davidson: "Chemical Aspects of the Cell Nucleus".

BRITISH PAPER AND BOARD MAKERS' ASSOCIATION, TECHNICAL SECTION, NORTHERN DIVISION (at the Engineers' Club, Albert Square, Manchester), at 7 p.m.—Dr. E. Waters: "The Psychology of Colour".

Saturday, November 4

ROYAL INSTITUTE OF CHEMISTRY (in the Zoology Lecture Theatre, The University, Reading), at 2.30 p.m.—Dr. G. W. Scott Blair: "Recent Developments in Rheology".

BRITISH INTERPLANETARY SOCIETY (in the Tudor Room, Caxton Hall, Westminster, London, S.W.1), at 6 p.m.—Mr. J. Humphries: "The Earth's Atmosphere"; Mr. T. R. F. Nonweiler: "Problems of High Speed Missiles entering the Atmosphere".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN CHEMISTRY up to special degree standard—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex (November 4).

ASSISTANT (female) IN THE ECONOMICS AND STATISTICS SECTION of the Commercial Department, at headquarters in London, for the collation, analysis and interpretation of statistics relating to the production, distribution and sales of electricity to consumers—The Director of Establishments, British Electricity Authority, British Electricity House, Great Portland Street, London, W.1, quoting AE.111 (November 6).

LECTURER and an ASSISTANT LECTURER IN GEOGRAPHY—The Secretary of University Court, The University, Glasgow (November 11).

ASSISTANT LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, Queen Mary College, Mile End Road, London, E.1 (November 13).

DIRECTOR OF THE NEW HORTICULTURAL CENTRE of the Ministry of Agriculture at Loughgall, County Armagh—The Secretary, Civil Service Commission, Stormont, Belfast (November 13).

REGIONAL DIRECTOR for the North Region of the County Advisory Service—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (November 13).

LECTURER IN PSYCHOLOGICAL MEDICINE—The Secretary of University Court, The University, Glasgow (November 15).

H.M. INSPECTORS OF FACTORIES, Class II (men and women), in the Ministry of Labour and National Service—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 3333 (November 16).

SCIENTIST, Grade III, on the staff of the Director-General of the Scientific Department at headquarters in London, for duties mainly concerned with progressing research work—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/265 (November 16).

AGRICULTURAL RESEARCH OFFICERS (with an honours degree in agriculture of an approved University or an equivalent qualification, and extensive knowledge of tropical or sub-tropical agriculture) in the Department of Research and Specialist Services, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (December 23).

AGRONOMIST in the Department of Agriculture, Gold Coast—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27059/249.

ASSISTANT SOIL CONSERVATION OFFICER in the Sudan Ministry of Agriculture—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Soil Conservation 4/196'.

ENGINEER (Hydrology) in the Public Works Department, Kenya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27322/192.

ENGINEER (Water Supplies) in Mombasa, Kenya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27329/27.

INDUSTRIAL CHEMIST or CHEMICAL ENGINEER as Assistant to Chief Chemist for new cement factory in Uganda—The Uganda Electricity Board, 129 Grand Buildings, Trafalgar Square, London, W.C.2.

LECTURER IN BACTERIOLOGY—The Principal, South African Native College, Fort Hare, C.P., South Africa.

UNIVERSITY DEMONSTRATOR for market research and analysis—The Secretary, Agricultural Economics Research Institute, Parks Road, Oxford.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Index to the Literature of Food Investigation. Vol. 20, Nos. 1–2, June. Compiled by Agnes Elisabeth Glennie, assisted by Margit Matthews and Igor Zacopanay. Pp. iv+90. (London: H.M. Stationery Office, 1950.) 6*s.* net. [247

Aluminium Development Association. Information Bulletin No. 17: Aluminium Alloy Castings. Pp. 48. (London: Aluminium Development Association, 1950.) 1*s.* [257

British Standard 18 : 1950, Tensile Testing of Metals. Fourth revision. Pp. 20. 2*s.* 6*d.* net. British Standard 868 : 1950, Cod Oil for Sulphonation, First revision. Pp. 16. 2*s.* net. (London: British Standards Institution, 1950.) [257

Medical Research Council. Special Report Series, No. 267: Researches on the Radioactivity of Oral Cancer. By Constance A. P. Wood and J. W. Boag (with P. Howard-Flanders, A. Glücksmann, L. H. Gray and F. G. Spear). Pp. 148+30 plates. (London: H.M. Stationery Office, 1950.) 12*s.* 6*d.* net. [257

Thirtieth Annual Report of the Board of the Institute of Physics. Pp. ii+12. (London: Institute of Physics, 1949.) [257

Bulletin of the British Museum (Natural History). Entomology, Vol. 1, No. 2: A Revision of the Family Ceracidae (Lepidoptera, Tortricoidea). By A. Diakonoff. Pp. 171–219. 10*s.* Entomology, Vol. 1, No. 3: The Early Literature on Mallophaga, Part 1. By Theresa Clay and G. H. E. Hopkins. Pp. 221–272+2 plates. 10*s.* (London: British Museum (Natural History,) 1950.) [257

Second Report of the Committee on Industrial Productivity. (Cmd. 7991.) Pp. 10. (London: H.M. Stationery Office, 1950.) 4*d.* net. [267

Third Annual Report of the Advisory Council on Scientific Policy, 1949–1950. (Cmd. 7992). Pp. 18. (London: H.M. Stationery Office, 1950.) 6*d.* net. [267

Registrar General's Statistical Review of England and Wales for the Year 1948. New Annual Series, No. 28: Tables, Part 1, Medical. Pp. viii+362. (London: H.M. Stationery Office, 1950.) 7*s.* net. [317

British School of Archaeology at Athens. Annual Report of the Managing Committee for the Session 1948–1949; Archaeology in Greece, 1948–1949, by J. M. Cook. Pp. 38+3 plates. (London: British School of Archaeology at Athens, 1950.) [317

The Task of Rationalism. By A. Gowans Whyte. Pp. ii+20. (London: Watts and Co., Ltd., 1950.) 6*d.* net. [317

General Register Office. Registrar General's Quarterly Return for England and Wales. Births, Deaths and Marriages, Infectious Diseases, Weather, Survey of Sickness, Population Estimates, Quarter ended 31st March 1950. Pp. 36. (London: H.M. Stationery Office, 1950.) 1s. net. [18

Library Association. Year Book 1950. Pp. 525. (London: Library Association, 1950.) 11s.; to Members of the Library Association, 8s. 6d. [18

Journal of Atmospheric and Terrestrial Physics. Editor-in-Chief, Sir Edward Appleton. (About every 2 months.) Vol. 1, No. 1. Pp. 64. (London: Butterworth-Springer Ltd., 1950.) 70s. per Vol. [148

City and County of Bristol: The City Museum. Report of the Committee for the Year ended 31 December 1949. Pp. 16+2 plates. (Bristol: City Museum, 1950.) [148

University of Reading: National Institute for Research in Dairying. Report for the Year 1949. Pp. 80. (Reading: National Institute for Research in Dairying, Shinfield, 1950.) [148

Wye College: Department of Hop Research. Annual Report, 1949. Pp. 55. (Wye: Wye College, 1950.) 3s. [158

Science Museum. One Hundred Years of Submarine Cables. By G. R. M. Garratt. Pp. viii+60+16 plates. (London: H.M. Stationery Office, 1950.) 2s. 6d. net. [158

Experimental and Research Station, Cheshunt. Annual Report (Thirty-fifth Year), 1949. Pp. 80+6 plates. (Cheshunt: Nursery and Market Garden Industries' Development Society, 1950.) [158

Air Ministry: Meteorological Office. Professional Notes No. 102: Sandstorms on the Northern Coasts of Libya and Egypt. By E. A. Lunson. (M.O. 524b.) Pp. 12. (London: H.M. Stationery Office, 1950.) 4d. net. [158

Birmingham and its Regional Setting: a Scientific Survey. Prepared for the Meeting held in Birmingham, 30th August–6th September 1950. (Published by the Local Executive Committee.) Pp. xix+334. (London: British Association for the Advancement of Science, 1950.) [168

Annual Reports on the Progress of Chemistry. Vol. 46, 1949. Pp. 334. (London: Chemical Society, 1950.) 25s. [168

Colonial Development Corporation. Annual Report and Statement of Accounts for the Year ended 31st December 1949. Pp. vi+70. (London: H.M. Stationery Office, 1950.) 2s. net. [168

Other Countries

World Health Organization. Technical Report Series No. 16: Joint FAO/WHO Expert Committee on Nutrition; Report on the First Session. Pp. 24. (Geneva: World Health Organization; London: H.M. Stationery Office, 1950.) 1s. 3d.; 15 cents. [177

German Hydrographic Institute, Hamburg. Annual Report No. 4, 1949. Pp. 68. (Hamburg: German Hydrographic Institute, 1950.) (177)

Journal of the California State Dental Association. Vol. 26, No. 3, May–June 1950, Supplementary Issue: Sugar and Dental Caries; a Symposium presented as part of the Eighteith Annual Meeting, California State Dental Association, April 24, 25, 26, 1950, San Francisco, California. Pp. 95. (San Francisco, California State Dental Association, 1950.) [177

Dominion Museum Records in Zoology. Vol. 1, Nos. 3–6: Papers on Mollusca. By R. K. Dell. Pp. 21–58. (Wellington: Dominion Museum, 1950.) [177

Smithsonian Institution: United States National Museum. Report on the Progress and Condition of the United States National Museum for the Year ended June 30, 1949. Pp. iii+123. (Washington, D.C.: Government Printing Office, 1950.) [177

Report and Accounts of the National Botanic Gardens of South Africa, Kirstenbosch, Newlands, Cape, and the Karoo Garden, Worcester, for the Year ending 31st December 1949. Pp. 20. (Newlands, C. P.: National Botanic Gardens of South Africa, 1950.) [177

Sveriges Geologiska Undersokning. Ser. Aa, No. 191: Beskrivning till kartbladet Untra. Av R. Sandegren och P. H. Lundegårdh. Pp. 107. (Stockholm: P. A. Norstedt and Soner, 1949.) 4 kr. [177

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 103, No. 6: Distribution and Origin of the Birds of Mexico. By Ludlow Griscom. Pp. 339–382. Vol. 103, No. 7: New and Little Known Cartilaginous Fishes from the Atlantic. By Henry B. Bigelow and William C. Schroeder. Pp. 383–408+8 plates. (Cambridge, Mass.: Harvard College, 1950.) [247

Report of the Scientific Advisory Board for the Year 1949. Pp. xii+307. (New Delhi: Indian Research Fund Association, 1950.) 1 rupee. [247

Geological Society of South Africa. Alex. L. du Toit Memorial Lectures, No. 1: The Life and Work of Dr. Alex. du Toit. By T. W. Gevers. Pp. 109. (Johannesburg: Geological Society of South Africa, 1950.) [247

British Territories in Borneo. Report of the Geological Survey Department for the Year 1949. By F. W. Roe. Pp. iv+106. (Kuching: Government Printing Office, 1950.) 2 dollars; 4s. 8d. [247

Universidad Nacional de Tucuman. Publicación No. 464 (Instituto de Física, No. 24): Correccion de la temperatura medidas con pirometros opticos y de radiacion. Por Jose Würschmidt. Pp. 28. Publicación No. 492 (Instituto de Física, No. 29): El sistema MKS y la ensenanza de la física. Por Jose Würschmidt. Pp. 24. (Tucuman: Universidad Nacional, 1949–1950.) [247

Commonwealth Scientific and Industrial Research Organization. Bulletin No. 247: Marine Crayfishes (Spiny Lobsters), family Palinuridae, of Western Australia; with particular reference to the Fishery on the Western Australian Crayfish (*Panulirus longipes*). By Keith Sheard. Pp. 45. (Perth: Government Printer, 1949.) [247

Australian Journal of Marine and Freshwater Research. Vol. 1, No. 1, April. Pp. 154. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1950.) 7s. 6d. [247

Impact of Science on Society. (Quarterly). Vol. 1, No. 1, April–June. Pp. 36. (Paris: Unesco, 1950.) 25 cents; 1s. 6d. [257

Fieldiana. Botany, Vol. 27, No. 1: Contributions to the Flora of South America—Studies on Andean Compositae, 1, Studies in South American Plants, 2. By José Cuatrecasas. Pp. 113. (Chicago: Field Museum of Natural History, 1950.) 1.75 dollars. [257

Iraq Natural History Museum. Publication No. 2: A Handlist of the Birds of Iraq (with Short Notes on their Status in the Country). Compiled by Bashir E. Allouse. Pp. 70. (Baghdad: Government Press, 1950.) [257

Pontificiae Academiae Scientiarum. Scripta Varia 7: Semaine d'étude sur le problème biologique du cancer. Pp. xiv+348+20 plates. (Citta del Vaticano: Pontificia Academia Scientiarum, 1949.) [257

Gold Coast Colony. Report to the Secretary of State for the Colonies by Dr. G. B. Jeffery on a Visit to West Africa, December 1949 to March 1950. Pp. 16. (Accra: Government Printing Department; London: Crown Agents for the Colonies, 1950.) 2s. [277

Unesco: Centro de Cooperación Científica para América Latina. Scientific Institutions and Scientists in Latin-America—Argentina. 2° volumen. Pp. ii+103. Scientific Institutions and Scientists in Latin-America—Brasil. 1er volumen. Pp. iv+139. 2° volumen. Pp. ii+305. (Montevideo: Unesco Centro de Cooperación Científica para America Latina, 1950.) [317

West African Cacao Research Institute. Annual Report, April 1948 to March 1949. Pp. 64. (Tafo: West African Cacao Research Institute; London: Crown Agents for the Colonies, 1950.) 5s. [317

City of Launceston. Annual Report of the Queen Victoria Museum and Art Gallery, 1948–49. Pp. 8. (Launceston: Queen Victoria Museum and Art Gallery, 1950.) [317

Indian Central Cotton Committee. Technological Bulletin, Series A, No. 72: Technological Reports on Standard Indian Cottons, 1949. By D. L. Sen. Pp. iv+75. 1.8 rupees. Technological Bulletin, Series A, No. 73: Technological Reports on Trade Varieties of Indian Cottons, 1949. By D. L. Sen. Pp. vii+91. 2 rupees. (Bombay: Indian Central Cotton Committee, 1949–1950.) [317

Ceylon. Part 4: Education, Science and Art (F). Administration Report of the Director of National Museums for 1948. By P. E. P. Deraniyagala. Pp. F. 17+2 plates. 55 cents. Part 4: Education, Science and Art (E). Administration Report of the Director of National Museums for 1949. By P. E. P. Deraniyagala. Pp. E. 26+1 plate. 55 cents. (Colombo: Government Publications Bureau, 1949–1950.) [317

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Hors Série. Recherches chimiques sur les alcaloïdes de l'Erythrophleum. Par Dr. R. Tonduer. Pp. 52. 50 francs. Série scientifique No. 47: Étude pétrologique d'un essai de fumure minérale de l'Elaeis à Yangambi. Par H. Laudelout. Pp. 21. 25 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1950.) [317

Beach Erosion Board. Technical Memorandum No. 16: Accretion of Beach Sand behind a Detached Breakwater. By John W. Handin and John C. Ludwick. Pp. v+13. Technical Memorandum No. 17: Test of Nourishment of the Shore by Offshore Deposition of Sand. By J. V. Hall and W. J. Herron. Pp. v+32. (Washington, D.C.: Government Printing Office, 1950.) [317

Government of India. National Fuel Research Institute: Opening Ceremony, 22 April 1950. Pp. 26. (Digwadih: National Fuel Research Institute, 1950.) [317

Uganda Protectorate. Working Plan for the South Mengo Forests, Uganda, for the Period 1948–1957. Plan prepared by R. G. Sangster. Pp. iii+76. (Entebbe: Government Printer, 1950.) [148

United States Department of Agriculture. Circular No. 842: Damage to Guayule by Insects and Mites, with Notes on Control. By T. P. Cassidy, V. E. Romney, W. D. Buchanan and G. T. York. Pp. 20. 10 cents. Miscellaneous Publication No. 698: A Revision of the North American Species of Beetles belonging to the Family Bostrichidæ. By W. S. Fisher. Pp. 157. 35 cents. (Washington, D.C.: Government Printing Office, 1950.) [148

Annals of the New York Academy of Sciences. Vol. 52, Art. 8: Antimetabolites. By D. W. Woolley and 29 other Authors. Pp. 1197–1378. (New York: New York Academy of Sciences, 1950.) 2.75 dollars. [148

Illinois Natural History Survey. Bulletin, Vol. 25, Article 3: Canada Geese of the Mississippi Flyway, with Special Reference to an Illinois Flock. By Harold C. Hanson and Robert H. Smith. Pp. 61–210. (Urbana, Ill.: Illinois Natural History Survey, 1950.) [148

Library of Congress. Microfilms and Microcards: their Use in Research; a Selected List of References. Compiled by Blanche Prichard McCrum. Pp. v+81. (Washington, D.C.: Library of Congress Card Division, 1950.) 55 cents. [148

Suomen Geodeettisen Laitoksen Julkaisuja. Veröffentlichungen des Finnischen Geodätischen Institutes. No. 37: Measuring of the 864m.-Long Nummela Standard Base Line with the Väisälä Light Interference Comparator and some Investigations into Invar Wires. By Tauno Honkasalo. Pp. 88. No. 38: On the Geoid in the Baltic Area and the Orientation of the Baltic Ring. By V. R. Ölander. Pp. 26. (Helsinki: Finnischen Geodätischen Institutes, 1950.) [148

Publications of the Isostatic Institute of the International Association of Geodesy. No. 24: On the Isostatic Structure of the Earth's Crust. By W. Heiskanen. Pp. 60. (Helsinki: International Association of Geodesy, 1950.) 1 dollar. [148

Papers of the Michigan Academy of Science, Art and Letters. Vol. 34, 1948. Editors: Eugene S. McCartney and Frederick K. Sparrow. Pp. xiii+352. (Ann Arbor, Mich.: University of Michigan Press; London: Oxford University Press, 1950.) 55s. net. [148

Fieldiana. Zoology Memoirs, Vol. 2: Amphibians of Western China. By Prof. Ch'eng-chao Liu. Pp. 409+10 plates. (Chicago: Chicago Natural History Museum, 1950.) 7.50 dollars. [148

Catalogues

Modulat Ovens. (GT.1372). Pp. 2. Glass Tubing Cutter. (GT.1389). Pp. 2. Microid Balances and Weights. (GT.1392). Pp. 12. (London: Griffin and Tatlock, Ltd., 1950.)

B.T.L. Bulletin and Laboratory Notes. Series 2, No. 16, May. Pp. 28. (Chadwell Heath: Baird and Tatlock (London), Ltd., 1950.)

A Digest of Edwards High Vacuum Equipment for Industry, Research, Education. Pp. 16. (London: W. Edwards and Co. (London), Ltd., 1950.)

Esso Magazine. No. 5, July. Pp. 20. (London: Anglo-American Oil Co., Ltd., 1950.)